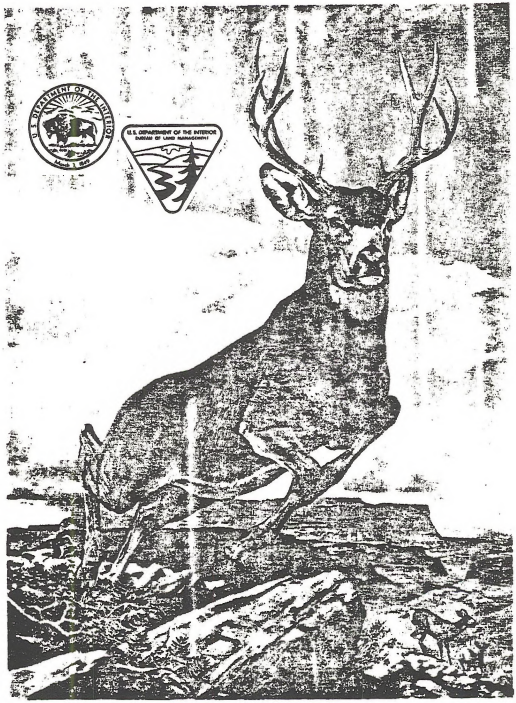
SPECIES LIFE HISTORY AND HABITAT REQUIREMENTS

MULE DEER



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A. Distribution.

1. Taxonomy. Odocoileus hemionus includes the mule deer and the black-tailed deer groups as differentiated from the white-tailed deer (O. virginianus). Eleven subspecies of O. hemionus are recognized; eight of these range within the United States. Of these, two subspecies on the west coast are commonly distinguished as black-tails and will not be included in this supplement. Taylor (1956) noted that as a species the northern three-fourths of the mule deer range, including an area largely subjected to ice inundations during the Pleistocene, is inhabited by one race. In the southern quarter of the range where deer probably have lived without interruption from the ages preceding continental glaciation, the mule deer has diversified into eight recognizable geographic races. Major emphasis here is on O.h. hemonius, the Rocky Mountain mule deer, which has by far the widest distribution of the subspecies (Taylor 1956). Other subspecies within our range are discussed below.

2. Historical. In pioneer times the mule deer range extended from the western provinces of Canada to and including Lower California and northern Mexico, all western states, the Dakotas, and western Texas. Seton, in 1929, reported mule deer gone from Kansas, Nebraska, much of South Dakota, eastern Colorado, and Oklahoma. Formerly reasonably common across the Canadian prairies, it is now scarce (Taylor 1956). In Colorado, before the advent of the fur trader in the early 1820's, game was plentiful, but by the year 1900 deer were in danger of extinction throughout the state (Hay 1961). In California, historical records indicate that deer may not have been as common in the high mountains as they are now, but they were numerous in the valleys and foothills (Dasmann 1962). Deer numbers were badly depleted at the turn of the century. Seton estimated 400,000 deer remained in the U.S. in 1909. Sparse Indian populations hunting deer probably had little direct effect upon populations, however fires set by the Indians must have influenced the range of the deer (Longhurst et al 1952).

Records of various parties of the 1820 and 1830 period indicate that deer were scarce over large areas of the western mountains and Great Basin country where today deer are abundant. Conversely, many of the original deer ranges (e.g., the Sacramento Valley) are now virtually deer-less because of agricultural development (Leopold 1950).

Deer seem to achieve maximum densities in areas of disturbed vegetation which produce palatable shrubs or tree reproduction as secondary stages in plant succession. Logging, fire, and grazing are the three principal influences.

Prior to settlement, deer seem to have occurred principally along edges where forest and grassland met or on recent burns in the forest.

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3. Present. The Rocky Mountain mule deer has the widest distribution of any subspecies of large game animal in North America. It extends over almost 30 degrees of latitude and longitude. This subspecies ranges from the summit of the Sierras, Cascades, and, in Canada, from the Coast Range, east to the Great Plains. Northward, the boundaries have extended to Great Slave Lake in the Northwest Territories, and south to central Arizona and New Mexico. The desert mule deer (O.h. crooki) extends northward from Mexico into southern Arizona, New Mexico, and Texas. The California subspecies (O.h. californicus) is distributed along the west slope of the Sierra Nevada from Sierra County, and the Coast Range from Monterey County, southward to the San Bernardino Mountains. The inyo deer (O.h. inyoensis) occupies the eastern slope of the southern Sierra Nevada and ranges eastward into the Inyo and White Mountains of California. The Southern subspecies (O.h. fuliginatus) has limited distribution in the southwest corner of California and extends into Lower California. The burro mule deer (O.h. eremicus) inhabits desert range along the Colorado River and adjacent areas in California and Arizona (Taylor 1956). The burro deer population is depleted, but not threatened with extinction (State of California 1965).

Generally, throughout the western range country, deer populations reached a low ebb in the early decades of this century, then, on favorable ranges, they increased rapidly through the late twenties and 1930's (Seton 1929, Longhurst et al 1952, Hay 1961, Dasmann 1962, Aldous 1949). The U.S. Forest Service estimated a 214 percent increase in numbers of all deer on national forests between 1921 and 1938, with a gradual rate of increase accelerating abruptly beginning about 1933. The old U.S. Biological Survey, in 1938, estimated the population of mule deer in the United States at not less than 1.5 million head (U.S. Senate 1940). Serious problems of overutilization soon developed on numerous ranges (Aldous 1949, Russo 1964). A number of western states now harvest more deer than their total population estimates of earlier years (Aldous 1949). Probably, there are more deer in California today than there ever were in primitive times (Dasmann 1962).

B. Habitat. Originally, mule deer occupied open country and ranged onto the plains far from timber. They depended more on flight than hiding. Essentially, they inhabited the lower hills and rough, partly wooded terrain (Seton 1929, Dixon 1934). An interspersion of vegetation types is preferred to large, unbroken stands of homogeneous vegetation. Deer, like many other species, frequent the edges of vegetation types (Dasmann 1957). The most productive deer ranges in America today are largely the result of land clearing, logging, livestock grazing, wildfire, homesteading, and other activities that changed the vegetation to lower successional stages (Dasmann 1971, Taylor 1956). Hill (in Taylor 1956) lists the principal mule deer habitat types as: Tall and short grass plains, particularly the shrub and hardwood sites and wooded stream bottoms; desert shrub, both the northern and southern types woodland, mostly pinyon-juniper; and conifer forest, particularly of the pine-Douglas fir type.

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Throughout central and eastern Montana, the ponderosa pine-Rocky Mountain juniper association, found on the uplands of the Missouri and Yellowstone River drainages, is the most important deer habitat, especially during summer. The Artemisia-agropyron (sagebrush-western wheatgrass) type ranked second and was especially used for feeding at the edge of timbered types. It increased in importance from fall through spring. Of 11,581 observations of deer over a 4-year period, nearly two-thirds (61%) of those feeding were on the Artemisia-Agropyron type (Mackie 1970). The pine-juniper type was intensively utilized during winter storms. Variations in occurrence of deer on the different types of habitat between seasons and years corresponded closely to changes in availability of preferred forage.

On the mountainous Front Range of north-central Colorado, at 6000 to 8500 feet, the areas of most intense winter use by deer were shrub and open timber with shrub understory types. During most of the winter, deer used the open-timbered/west-facing and the shrub covered/south-facing exposures where temperatures were highest (Loveless 1964).

Forage is the chief factor affecting the distribution of deer on Utah summer ranges and one of the chief factors on winter ranges. Deer usually prefer the more productive forage types. Areas having a good variety of forbs and shrubs with adequate protective cover interspersed are particularly desirable. On summer range in central and northern Utah, deer preferred the aspen and mountain shrub types to all others. When summer range is seriously overstocked, deer make greater use of the intermediate mountain-brush zone, normally spring-fall range. On a summer range at 8-10,000 feet in northeast Utah, deer preferred the mixed shrub (chokecherry, serviceberry, and snowberry), gambel oak, and the aspen types in that order. Preferences changed with the season. They preferred oak type in early spring, later moved to conifer-shrub, mixed shrub, and aspen types (Julander 1966, Julander and Jeffery 1964).

During winter in northeastern Utah, local deer numbers were determined by availability of food, snow depth and condition, temperature, wind, and the amount of protective cover. During the most severe weather, deer found shelter in heavy juniper stands. During severe winters, deer occupied only 60 percent of the area used during normal winters, with upper range limits at 6500-7000 feet elevation (Richens 1967).

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Mule deer occupy all life zones of New Mexico and Arizona. The Rocky Mountain subspecies inhabits the northern timber and alpine types, as well as the pinyon-juniper woodland and oak-brush intermediate ranges. The Desert subspecies occupies the pinyon-juniper woodlands, chaparral, and the arid desert flats and rocky hills of the bighorn sheep and javelina ranges of the south--principally the Guadalupe and San Andres Mountains (Lamb 1971, Lang 1957). The pinyon-juniper woodland is valuable winter, and sometimes yearlong, range (Reynolds 1964). On the foothill ranges of Fort Stanton, in south-central New Mexico, deer showed a preference for the mixed brush type (oak, juniper, skunkbush, and others) over the pinyon-juniper, oak or grassland (Wood et al 1970).

The principal spring-summer-fall range types in northern Arizona are ponderosa pine (6000-8000 feet) and spruce-fir (8000-12000 feet) (Reynolds 1969). In the Arizona chaparral (3000-7000 feet) the most abundant shrubs are: shrub live oak, skunkbush, mountain mahogany, manzanita (Arctostaphylos pungens), and emory oak (Hanson and McCulloch 1955, Swank 1958). On arid ranges, the desert shrub type (carnegiea, opuntia, Prosopsis, and acacia species) is most important (Urness et al 1971).

On the Kaibab Plateau, the border zone along the forest edge, in both opening and forest, received the heaviest use. Use decreased on either side of the zone. There was some deer use at the greatest distances measured into the forest. In pine forests, deer use occurred out to 1200 feet from the forest edge into openings; in the spruce-fir forests, use did not extend beyond 600 feet (Reynolds 1969).

In northern Arizona, deer preferred an old pinyon-juniper-sagebrush burn for fall-winter range. Greatest use was made nearest the unburned woodland. Optimum width of such a burn appeared to be less than one-quarter mile, but the large population present made heavy use of the one-quarter to one-half mile zone (McCulloch 1969).

On the timber-type summer ranges of northern Arizona, use varied with overstory character and density, and the presence of forest openings (Reynolds 1969). Shrub density declined where the tree overstory exceeded about 150 trees per acre. Tree density can be either too high or too low for best deer habitat. Shrubs were more important than trees as habitat (Reynolds 1964).

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In the spruce-fir forests, deer preferred the forest to natural openings of up to one-hundred acres by 3:1. They preferred created openings (10 to 30 acres in 6-year old clearcut) to natural openings. Vegetation composition of natural openings was 98 percent perennial grass. On the clearcuts, forbs amounted to 68 percent of the total. Deer use was greatest at the forest border, with little use in openings larger than 20 acres. On an old selectively logged ponderosa pine site, deer used the natural openings of up to 40 acres, borders, and forests about equally. Deer use in openings changed little up to about 700 feet from forest edges. Small openings up to about 35 acres were utilized throughout (Reynolds 1962A).

BLM-University of Nevada cooperative studies of Nevada ranges indicate that quaking aspen with some serviceberry, snowberry, and chokecherry is important summer habitat at 8000 feet and above. Communities rich in forbs were heavily used. Extensive stands of low sagebrush on open ridges received little use. Winter ranges in the northeast and central part of the state at 6500-8500 feet elevation are principally pinyon-juniper on upper slopes, sometimes with sagebrush, mountain mahogany, or bitterbrush. Lower slopes support big sagebrush, often mixed with desert bitterbrush, desert peach, or skunkbush. The most important winter range types included bitterbrush, mountain mahogany, snowberry, or serviceberry species. Stands of pure big- or low-sagebrush rated low in deer use (Berg 1966, Depaoli and Tueller 1970).

Winter range studies in central Oregon showed that deer only made major use of juniper (J. occidentalis) stands during storms and low temperature periods. They were little used during mild weather; preferred forage was not available there. Between storms deer moved to short vegetation and available forage. Deer occupied ponderosa pine timber in mild winters. Communities with bitterbrush were preferred in fall and winter. Deer utilized crested wheatgrass seedings at critical times, before most native grasses began growth. They shifted to grasses when spring growth began, even though bitterbrush remained available. Species composition determined the value of plant associations (Leckenby 1968).

In British Columbia-Alberta national parks not more than perhaps 10 percent of the area carries the game herds through the five-months winter season (Cowan 1950).

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In California, the Rocky Mountain and burro subspecies prefer open woods and broken rock country. The California subspecies is more like the Columbian blacktail in preferring brush; it is a characteristic inhabitant of the chaparral belt. In the Sierras they inhabit pine forests and graze open meadows (Dixon 1934). Frequent burning helps to maintain a high carrying capacity. On the west slope of the Sierras, deer winter on benchlands at elevations of 500 to 2000 feet in the north and 3000 to 5000 feet farther south. East of the Sierras (Great Basin) and Cascades, the winter ranges in ponderosa pine and sagebrush types range between 3000 to 5000 feet (Longhurst et al 1952). On the west slope of the Sierras, in central California, summer ranges were in ponderosa pine, red fir-jeffrey pine, and alpine types. Winter ranges were in the ponderosa pine, and the chamise-digger pine-white oak types. The summer range in this area was seven times the area of the winter range. It is generally above 5000 feet elevation and includes extensive brush areas due to logging and burning. Approximately one-half of the year is spent on winter range and it is the key to the population being able to exist on the whole herd range (Leopold et al 1951).

The ideal habitat for deer in the oak-woodland area of California seems to be a mixture of cover types with an interspersion of unburned chaparral for escape cover, burned chaparral for nutritious browse, grassland for winter protein, and mature oaks for both browse and acorn production (Longhurst 1969).

C. Life History.

1. General. The mule deer breeding season, in general, is earliest in the north and coastal locations, and occurs later southward and inland. The peak of activity generally is given as cited below; however, dates may be earlier or later in local situations.

Table 1. Breeding Period (Dasmann 1962, Dixon 1934, Long 1957, Leopold et al 1951, Swank 1958, Taylor 1956)

Subspecies	Location	Breeding Period	Fawns Born
Rocky Mt.	Canada, Oregon, Nevada, Utah, Colorado	Late Oct.-Nov.	June
	California	Mid-Nov.-Dec.	July-Aug.
	Arizona, New Mexico	Dec.-Jan.	July-Aug.
Desert	New Mexico	Dec.-Jan.	July-Aug.
California	Calif. coastal	Sept.-Oct.	April-May
	Calif. interior	Nov.-Dec.	July
Southern	Calif. coastal	Mid-Sept.-Oct.	April-May
	Calif. interior	Nov.-Dec.	July
Inyo	California	Dec.-Jan.	July
Burro	California	Jan.-Feb.	July-Aug.

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Does usually breed at 16-18 months of age. Hybridization between races of mule deer, including black-tails, apparently is not uncommon. Crosses between mule and white-tail deer have been reported (Dixon 1934). Gestation period is approximately seven months. Younger does usually have a single fawn; twins are more common among older does. Triplets occur rarely. On poor condition range there are fewer twins and fewer young does produce fawns. Weight of deer at birth is about 5½-7 pounds. Fawns do not follow does during their first few weeks. They begin sampling forage when 2-3 weeks old, but continue to nurse for about three months and are weaned by fall. Weaning time is critical as suitable green forage must be available. Fawns grow more rapidly during the first summer than at any other time. They build less reserve fat than older deer. Their spots fade out during the first few months and are usually gone by fall. Most young males leave the mother when 9-12 months old; young females usually remain longer. Deer groups are smallest in summer (Dasmann 1962, Dixon 1934, Leopold et al 1951, Swank 1958, Taylor 1956 (Einarsen, Hill), Lang 1957). Deer seldom live beyond 10 years. In captivity, under excellent conditions, twelve years is about the maximum. Life expentancy of the males is considerably less than that of females, even where man is not a factor (Cowan 1950, Lang 1957, Taylor-Einarsen 1956). Annual increments of 25-30 percent of a herd appear to be necessary to replace annual mortality (Mackie 1966).

2. Weights. The mean live weight of 53 deer collected on the Interstate (California-Oregon) winter range was 123 pounds (range 92-150 lbs.) (Interstate Deer Herd Comm. 1947). The average live weights of 163 deer from a west slope of the Sierra wintering area in central California were: young, 49-47 pounds (male-female); yearling, 85-77; adult 135-102; old bucks 140, and old does 101 pounds (Leopold et al 1951). Field-dressed weights (approximately 70 percent of live weight) of fall-harvested adult bucks on the Kaibab range in Arizona steadily decreased (1945: 192 lbs.; 1954: 124 lbs. average) as the population multiplied and the range deteriorated. Following the major die-off in 1954, average weights increased and had nearly recovered by 1963 when the mean reached 186 pounds (Russo 1964, Swank 1958). In Utah, Stoddart and Rasmussen (1945) recorded another example of the effect of range condition on deer weights. The average fall weights, hog-dressed, of 3500 deer taken on good range were: Bucks 141, does 101, and fawns 55 pounds. The comparable averages of 289 deer taken on poor range were: Bucks 103, does 71, and fawns 38 pounds. Leopold et al (1951) recorded average weight loss during the winter by the bucks retrapped was 36 pounds. They believed that many deer probably do not survive a 25 percent loss of weight.

D. Movements.

1. Home Range. Deer have a strong instinct to return to the same seasonal ranges each year. Home range is the area an animal covers in its day-to-day travels. In Utah, some areas on winter ranges are little used while deer concentrate on other areas and may starve rather than

move to a new range (Julander 1966). Seasonal movements vary in summer with the stage of growth of forage plants, and in winter with snow depth, temperature, and wind movement.

Robinette (1966), in west central Utah, observing numerous marked deer over a period of years, determined that the home range of bucks exceeded that of does and fawns by about 50 percent. The activity radius of males was just under 500 yards and for antlerless deer it was less than 400 yards. This concept of home range recognizes greater use near the center of the range. A radius of about 750 yards would be necessary to contain about 90 percent of the average doe's activities. Factors which could influence home-range size, in addition to the sex and age of the animal, include heredity, population density, topography, season, rutting activities, and the availability of food, water, and cover (e.g. losses due to fire). Dispersal, as defined here by Robinette, is movement of animals more than a mile from the area of birth and establishing a new home range. This was most common among yearlings. Sixty percent of bucks and 35 percent of does had apparently dispersed by the time they were 16 months of age. There was little separation of young from adult does until a new fawning season began. Yearlings seen with does in the fall are not necessarily their offspring. Dispersal provides a barrier to inbreeding, a means for invading new habitat and reinvading formerly inhabited areas, and for redistribution of animals following localized decimation (Robinette 1966).

In Montana, home ranges of does were approximately one-half square mile. Males were more mobile and less uniformly distributed, especially during summer and early fall. Recognizable animals seldom moved more than one or two miles between observations. The maximum summer movement of fawns was limited to about one-half mile. Food preferences and availability appeared to be the primary factors influencing these movements (Mackie 1970). In northeastern Nevada, Gruell (1958) reported that deer movements during the summer months are limited to one square mile or less.

In Arizona chaparral, the home range of individuals varied from a mile to about two and one-quarter miles in diameter--most did not exceed one and one-half miles during three years of study. There was no indication that deer shifted their home range during the different seasons to take advantage of favorable food conditions. Does with fawns ranged about the same as other adults. Adult bucks may range somewhat farther than does, the area averaging around two miles in diameter. Rutting bucks, however, may leave their home range (Swank 1958, Hanson and McCullogh 1955).

In the Yosemite area of California, individual deer sometimes remained for days in an area not over one square mile. During midsummer or mid-winter daily movement was much less than during spring and fall. On summer and winter ranges, when not disturbed, individuals may have a monthly range of not over one township (Dixon 1934).

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In the vicinity of Sequoia National Park, studies with marked deer indicated that most does on summer range remained within an area of about one-half mile radius (Schneegas & Franklin 1972).

Leopold and co-workers (1951) found the average home range during summer (one-half to three-quarters mile in diameter) was twice the diameter of winter home range. In winter, bucks ranged over about 90 acres; does averaged 17 acres. Every adult deer seemed to have a highly specific and localized home range to which it returned each winter. Yearlings, especially males, wandered without definite home ranges (e.g. two marked males went 32 and 48 airline miles from the point of marking). Dasmann (1971) estimated that on the average, mule deer range over about one-half square mile on the winter range and one square mile on summer range.

2. Daily Movements. In Montana, deer were most active within 3-to 4-hour periods in early morning and late afternoon--especially during the first and last hours of daylight. This was independent of season, weather, forage condition, animal numbers or density. At below zero temperatures, 25 percent of the observations occurred during the first and last hours of daylight as compared to 60 percent when temperatures exceeded 80° F. (Mackie 1970). Loveless (1964) in Colorado, found that during winter deer were active in daylight, but during the warm spring period much of the feeding activity was at night. In Arizona, deer were feeding at all hours during the winter, but were most active early in the morning and late in the evening throughout the year. During hot weather, most deer bedded within 2 hours after daybreak and were seldom up prior to 1 hour before darkness. The deer finished evening foraging by 2 to 3 hours after darkness. The habitual watering area appeared to be the center about which daily movement revolved--especially during summer (Swank 1958).

In Arizona chaparral, the daily cruising radius was about one mile. Deer frequently moved one-half mile during the morning feeding. Disturbed deer might run up to one mile (Hanson & McCulloch 1955).

3. Migration. The mule deer is migratory in most of its range. It usually moves only as far as forced to by snow rendering food plants unavailable and travel difficult. Snow depths of 8 to 10 inches seemed to initiate movement in Utah. The general fall movements start with the first fairly severe, general snow storm. The movement is rapid if storm conditions are continuous. The bulk of the movement may occur within a one-week period or it may slow down if mild weather returns. Deer may remain at middle elevations until forced down by later storms. In most sections, deer habitually migrate to the same destinations and by the same general routes each year. Spring migration coincided with rising temperatures, snow melt, and growth of green forage. Sizeable drops in temperature, especially with wind or snow, generally temporarily delayed spring movement. The upward drift in spring may be gradual and correlated most closely with availability of green vegetation. This movement may take several months (Richens 1967, Leopold et al 1951).

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Table 2. Migration Periods

Location	Fall	Spring	Literature Cited
California	Oct-Nov	Apr-May	Leopold et al 1951
W. slope Sierras	Oct-Nov	Apr-June	Longhurst et al 1952
Yosemite	Oct-Nov	Apr-June	Dixon 1934
Sequoia	Oct	Apr-May	Schneegas et al 1972
Cal-Ore	Oct	Mar	Interstate Comm. 1947
Colorado	Oct-Nov	Apr-May	Bartmann 1968 Loveless 1964
Idaho	Nov-Dec		Jensen 1968
Nevada	Sept	Mar-May	Papez 1967
Oregon	Oct-Nov		Zalunardo 1965
Utah	Oct-Nov	May-June	Richens 1967

Seasonal elevation changes of 3000 to 5000 feet seem to be general in the mountain west, although this varies with the severity of the winter (Jensen 1968, Loveless 1964, Gilbert 1970, Dixon 1934). Normally, this requires a change of vegetation type, such as from ponderosa pine to sagebrush in Oregon or to cliffrose and mahogany in northern Arizona (Zalunardo 1965, Swank 1958). In Colorado, deer occupy the spruce-fir-lodgepole zone up to 11,000 feet in summer, and they winter mainly in pinyon-juniper at 5500 to 7500 feet on south slopes (Bartmann 1968). In central California, mule deer may summer on mountain meadows at elevations up to 12,000 feet and winter in the oak covered foothills at 3500 feet or less (Dixon 1934). It is not uncommon for these wintering areas to be restricted to a small fraction of the area available in summer (Richens 1967). In many places, the ratio of winter to summer range is approximately 1:15 (Aldous 1949).

Some deer move only a few miles down slope to winter range; others move long distances, sometimes crossing ridges and drainages to winter in habitat similar to that of closer ranges (Gruell 1958, Richens 1967). Deer summering together may go to different winter ranges (Papez 1967). In some areas mule deer are nonmigratory. In the breaks of the Missouri River in central Montana, deer moved less than 2 miles to bottomlands as the upland vegetation dried (Mackie 1970). Deer tend to be nonmigratory in southern California. Dasmann (1962) and Dixon (1934) reported that deer may not migrate if suitable food remains available. In the northern chaparral zone of Arizona, deer occupy distinct summer and winter ranges (Swank 1958). In central Arizona, chaparral is used as winter range by many deer which summer in adjoining coniferous forest. In most of the chaparral region, deer are resident yearlong (Hansen & McCulloch 1955).

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Lang (1957) in New Mexico, reported that the Rocky Mountain subspecies does little shifting in open winters and seldom exceeds 3 to 5 miles in average or severe winters. The Desert subspecies usually occupies a locality year-round.

Table 3. Migration Distances

Location	Distance Average (Range) (Miles)	Literature Cited
California		
Cal-Ore Interstate	70	Longhurst et al 1952
Tehama	30-50 (to 100)	Longhurst et al 1952
Warner Mt.	5 or less	Longhurst et al 1952
W. slope Sierras	10-20 (to 50)	Leopold et al 1951
Sequoia	18	Schneegas et al 1972
Yosemite	5-50 (to 70)	Dixon 1934
Colorado		
White R (226 deer)	55 (to 92)	Bartmann 1968
Idaho (205 deer)	9 (1-150)	Jensen 1968
Nevada (12 deer)	66 (40-89)	Gruell 1958
Oregon	19 (1-60)	Zalunardo 1965
Utah	30 (to 100)	Richens 1967

The homing instinct is quite strong in mule deer. However, deer wintering together do not necessarily summer together and vice versa. Trapped and marked deer are commonly retrapped at the same or at nearby sites in succeeding years. For example, of 157 marked deer on a central Oregon range, 112 were always retrapped at the same trap. The 45 others averaged three-quarters of a mile from the original trap site. Rarely are deer recovered on winter ranges other than where originally trapped (Gruell 1958, Jensen 1968, Leopold et al 1951, Zalunardo 1965). Animals marked on the winter range have been observed on the same summer range in different years: e.g., in Nevada, 12 deer migrated an average of 66 miles to the same summer range in three different years (Gruell 1958). Bartmann (1968), in Colorado, recorded one instance of a doe retrapped on a winter range 70 miles from the point of original capture. Yearlings, especially males, wander without definite home ranges. Leopold et al (1951) reported two cases of marked yearling males taken on distant ranges--one 32 and one 48 airline miles. Jensen (1968) noted a yearling male that travelled 150 miles from southeastern Idaho to Cody, Wyoming.

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E. Habitat Factors.

1. Critical Seasons. The most critical time of the year for deer on northern and mountainous ranges generally is the late winter and early spring before the start of green growth. On the drier, southern ranges the critical time is during droughts or prior to the start of the rainy season when there is a scarcity of water and green feed (Dasmann 1957, DeNio 1938, Julander 1966, Longhurst et al 1952, Papez, 1967, and Swank 1958).

Two factors are primarily responsible for critical winter conditions: (1) Forage of inadequate nutritional quality and abundance, and (2) snow which limits the amount of accessible range (Gilbert et al 1970). Browse foods usually dominate the diet during critical periods. It is the amount of high quality winter forage that determines the carrying capacity of these ranges (Leopold et al 1951). Ninety percent reduction in accessible range in winter is not uncommon. On the Oregon-California Interstate herd winter range, one-sixth of the area receives two-thirds of the winter deer use (Taylor et al 1956).

In certain areas, as in southern Utah, summer range is the limiting factor, and deer losses may be heavy in drought years, especially on overstocked ranges (Julander 1966). On the south coastal ranges of California, the dry, late-fall season is usually most critical (Dasmann 1957). In southern Arizona, most die-offs occur in June during droughts. There appears to be a direct correlation between winter precipitation (October to April), which in much of Arizona controls the amount of forage produced, and the overwinter survival of fawns (Swank 1958).

Usually, deer populations maintain a rough balance with a fluctuating food supply. Occasionally, the water supply, and less frequently the available cover, may be the limiting factor. The size of a range may also limit the number of deer it can support. Recent studies indicate that spatial limits do exist. An abundance of high quality food on the summer range is needed by lactating does and enhances the survival of their fawns. High fawn production and survival to early winter are good indicators of adequate summer range. Declining summer range condition usually is followed by a decrease in deer numbers and a decline in the physical condition of the animals (Dasmann 1971).

2. Physical Factors.

a. Slope and Aspect. Mackie (1970), studying deer in the Missouri River breaks of central Montana, reported that yearlong, over a 4-year period, more than one-half of 11,581 animals observed were on 0-10 percent slope. Approximately 75 percent of the total observed deer were on less than 25 percent slope.

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On northern Colorado winter ranges, deer avoided the warmer, exposed sites during the warm early-fall season. With colder weather, use of the warmer south- and east-facing exposures increased and the deer became more concentrated. Approximately 50 percent of the shrub species on the north exposure and in the valley were covered by snow during much of the winter, on the west exposure 20-25 percent, and on the south and east exposures less than 15 percent (Loveless 1964).

In Utah, on cold, sunny, winter days most deer occupied bare southern slopes where temperatures were highest and snow depth least. Northern slopes were used heaviest in fall and spring but were abandoned during the winter when they were covered with deep, crusted snow (Richens 1967). In severe weather, deer use south and west exposures with protective cover. During periods of deep, crusted snow and cold weather juniper, pinyon and some taller shrubs furnish both cover and emergency forage. In early spring, deer concentrate on green forage found first on south and west exposures. Steepness and roughness of slope have little direct effect on deer distribution if suitable forage is available. Most suitable habitat is occupied within the home range of a herd at some time during the year (Julander 1966). On summer range, deer preferred the upper slopes, major ridge tops, and middle slopes with heaviest use on slopes of 30 percent or more and with highest shrub density (Julander and Jeffery 1964).

In northern Arizona, deer readily used slopes of up to 40 percent during summer. Use was highest on north-eastern exposures where cover density was good (Reynolds 1964). Slope and exposure have a minor role in southern New Mexico (Wood et al 1970).

b. Temperature and Wind. Wind induces little reaction in deer except during very cold weather (below 15° F.) when they avoid exposed situations and usually seek the cover of green timber.

In northern Colorado, the temperature level which triggered obvious concentrations appeared to range between -10 to 5 or 10 F., but humidity and wind were important factors. During winter, deer sought the most favorable temperature zones and areas having the most direct sunlight. On warm spring days deer preferred shade. When temperatures were high (and humidity low) deer activity declined (Loveless 1964).

Along the Missouri River in central Montana, deer were in timbered types at temperatures below 0° and above 80° F., and at wind velocities above 10 miles per hour (Mackie 1970). In western Montana, cold winds and low temperatures were more influential on game movements than were snow conditions (DeNio 1938).

Studies of white-tailed deer indicate that at temperatures below 30° F. they lose weight rapidly no matter how much or how nutritious the food supply (Dasmann 1971).

c. Snow Depth. Data on the effect of snow depth on deer varies with different authors; however, twenty inches of loose snow, less if crusted, apparently is about the limit for wintering mule deer, although they will maintain trails across deeper drifts if feeding areas remain more open. Deer will nose and paw through light snow for forage (Taylor et al 1956).

Gilbert et al (1970) reported that of 4442 observations in Middle Park, Colorado, 88 percent of the deer were in areas where general snow depths were less than 18 inches. Most of the remainder were moving to lower areas. Ninety-three percent of all deer observed were standing where snow depth was less than the depth of their hocks (17-18 inches on adults). Snow over 18 inches deep essentially precludes use of the range by deer. In a winter with considerable snow, deer finally concentrated in less than one-quarter square mile of the ten square mile area accessible during the previous winter.

On the Front Range of Colorado, Loveless (1964) found depths of 10 to 12 inches impeded deer movement, especially of yearlings, and depths of 20 to 24 inches essentially excluded them.

Among other references to snow depth limitations, Mackie (1970) reported that deer moved out of 15 to 24-inch depths in the Missouri River breaks. In northeastern Utah, 8 to 12 inches of snow seemed to be the decisive depth to initiate deer movement (Richens 1967). Dixon, in California, declared deer were numerous where average snow depth was 18 inches. In western Montana and northern Idaho, DeNio (1938) reported that in general, deer will readily paw for food through 30 inches of snow beyond which depths they migrate or exist on heavy browse and conifers.

3. Cover. Protective cover is especially important in influencing deer distribution in midwinter, at fawning time, and during hunting seasons. Protective cover adjacent to adequate forage is a critical factor in the survival of deer in severe winters (Julander 1966). The need for cover varies with local or regional conditions. In the absence of severe climate and of enemies, deer appear able to get along with a minimum of cover. Cover can be provided by topography as well as vegetation. Use varies with seasons and time of day. Deer tend to remain in cover during severe weather. Escape from cold winds conserves body heat. Possibly, deer experience less heat loss on winter ranges where cover is adequate and thus might survive at a lower plane of nutrition than would otherwise be possible. Ordinarily, deer will not deplete their own cover except where important cover species also are important deer foods. It is unusual to find deer much more than 400 yards from cover. Deer prefer edges of vegetation types (Dasmann 1957, 1971). Richens (1967) found that in northeastern Utah large sagebrush flats were used most heavily around the edges. The heaviest use of sagebrush was generally within one-quarter mile of pinyon-juniper or other escape cover. Skovlin et al (1968) found small grassland openings adjacent to dense forest cover generally received heavier use than larger grassland openings.

At night, in Arizona, deer frequently bedded down on open ridges but daytime beds were usually located in dense cover (Swank 1958). Creating openings in dense cover or providing woody cover where it is lacking can increase useable habitat. Any improvement of cover for deer should aim to create interspersions of food, water, and cover, all within a short radius--preferably about one-half mile (Dasmann 1957). See also "B. Habitat" for relevant material.

4. Food. Food is usually the weakest point in the food-water-cover triangle. It is the one habitat factor that deer themselves deplete. Food requirements include both quality and quantity minimums. Food conditions during the summer and fall preceding the rutting season appear to be the major factor controlling the number of fawns developing per doe. In the winter it is possible to have two critical periods: first, the concentrations and food scarcity caused by deep snow; the second occurs in early spring when green growth is high in water and low in nutritive value (Dasmann 1971, DeNio 1938, Swank 1958). Ordinarily, deer will not survive a winter weight loss of more than 30 percent of autumn weight (Doman and Rasmussen 1944).

Studies on white-tailed deer showed that antler size is governed largely by the quality of the food eaten by the buck while his antlers are developing--even though he was on poor range the previous winter. Antler development in yearling deer is a good indicator of the adequacy of the food supply, since antlers are grown with resources available after body maintenance needs are met. Does, however, if wintered on inadequate foods, may lose about 30 percent of their young even if spring foods are plentiful. But if spring forage is also inadequate, losses of young may amount to 50 to 90 percent (Dasmann 1971).

Longhurst (1969) found indicators of forage conditions to be body weight, weight of rumen content, blood urea nitrogen levels, and number of fetuses.

a. Quantity. The forage requirement of an herbivorous animal is in relation to the heat-radiating surface area of the animal rather than directly in relation to size or weight. On an air-dry basis this is about 2.8 pounds for a 100 lb deer, 3.9 lbs. for a 150 lb. deer, and 4.8 lbs. for a 200 lb. deer. Younger animals have the highest forage requirement. Numerous studies show that deer need from 2.4 to 2.8 lbs. air-dry forage/day/cwt, or from 5 to 7 lbs. of green browse (Dasmann 1957, 1971).

Nichol (1936) found the daily native forage requirement of captive deer of mixed sexes and ages, over a 3.5 year period, averaged 2.35 lbs./cwt.

Hill (in Taylor, 1956) stated the requirement of penned deer on native range feeds was about 3 lbs. air-dry/cwt/day.

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Doman and Rasmussen (1944) reported that 3.1 lbs. air-dry forage (including alfalfa, barley, etc.) per hundredweight will maintain deer during winter in Utah. Alfalfa was a good supplement with browse. Regarding emergency feed, Dasmann (1957) reported that a 50 lb. cake containing 45 parts by weight of cane molasses and 55 parts of coarsely ground soy beans would last 8 deer for 10 days and produce gains.

In Utah, penned deer fed 12 diets of native forage over a two-year period had a daily requirement of 3.11 lbs. air-dry forage/cwt/day (Rasmussen and Doman 1943).

Smith, working at Logan, Utah, fed captive deer commonly available local plant species during a series of tests. In 1950 (Smith 1950a), two deer, fed a selection of 17 species of browse for ten weeks, January to March, consumed an average of 2.7 and 2.6 lbs. per day, air-dry. Less than one-half pound was big sagebrush. Both deer lost about 12 percent in weight. In another study (1953), two deer, fed herbs and browse for two summers, ate an average of 3.67 and 3.16 lbs. per day. During three winters, 1954-57, four deer, fed a mixed diet of shrubs, consumed 2.25 lbs. per hundredweight per day. During an 18-day familiarization period, prior to the 1954 test, four deer ate an average of 2.7 pounds (range 2.1 to 3.4) per hundredweight (Smith 1959). Smith (1953) found that forage consumption increased with cooler weather.

In plot studies, Richens (1967) found 3.5 pounds of air-dry forage was removed per deer-day on a winter range in the Uinta Mountains of Utah (Table 4).

Table 4. Forage Removal by Vegetation Type on a Utah Winter Range. Data Based on 845 - 1/100 Ac. Plots. (Richens 1967)

Type	Days/Ac	Lbs/Ac (Air-day)
Bitterbrush	49	174
Mountain Mahogany	46	163
Sagebrush	33	114
Desert shrub	21	75
Pinyon-juniper	14	51
Average	32.6	115.4

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Range production of browse probably averages about 250 pounds air-dry per acre annually of current season twig growth. Bitterbrush in California may produce 900 lbs/acre. Plots in Colorado produced 291 lbs. air-dry, bitterbrush and 262 lbs. big sagebrush. A mountain mahogany type in the Black Hills, S. D., produced 118 lbs/acre (Hill in Taylor, 1956). Typical stands of gambel oak in Arizona averaged about 300 lbs. of mast per acre (Reynolds et al 1970).

b. Quality. The quality of forage for deer is determined by: (1) the levels of important nutrients contained in the portion eaten, (2) the ability of the animal to digest these nutrients, and (3) the efficiency of the digested nutrients to meet the physiological demands of the body, for maintenance, growth, reproduction, and other activities. In assessing forage quality for ranges, the end results are measured by animal performance which is determined largely by the ability of the rumen micro-organisms to use the supplied nutrients efficiently (Dietz 1965). Neither chemical content nor digestible nutrients is an adequate measure of a plant's value as forage. The animals reaction toward the plant needs to be assessed. A plant may have high value in a mixed diet and be inadequate as the sole diet (Smith 1959).

(1) Nutritional levels of staple forages should be determined during periods when they are being utilized. The nutrients most important to measure are probably dry matter, crude protein, lignin or crude fiber, ash, and phosphorus. Gross energy figures are valuable if digestible or metabolizable energy can also be determined. Very high protein levels are inefficient for ruminant animals. Lignin or crude fiber represent indigestible material. In general, there should be no carbohydrate deficiencies where there is a sufficient amount of palatable forage.

Crude protein content is a good index of the food value of a plant. Deer may select only the most nutritious parts of plants. Browse plants that maintain high crude protein levels during their dormant periods are usually most important on a deer range. The critical protein level for animal maintenance is about 7 percent. Studies indicate that 13-16 percent is needed for optimum growth (Dasmann 1971). Longhurst et al (1952), in California, reported that up to 40 percent of a deer herd starved at less than 7 percent protein in the diet. Protein cannot be stored in any appreciable quantity and is a critical element in day-to-day nutrition. Animals on an inadequate protein diet are less able to digest low quality forage.

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Phosphorus is reportedly deficient in many forage species on western game ranges during the winter season. It might adversely affect fawn production. Minimum phosphorus levels for deer appear to be about 0.16 to 0.25 percent. The desired calcium-to-phosphorus ratio is between 1:2 and 2:1. With the possible exception of protein and phosphorus, the most common nutritional deficiency of deer is lack of either available energy, digestible energy, or both. The shortage of energy-producing feed is most common on over-browsed deer winter ranges and on early spring ranges when deer switch to lush green forage. A poor winter range will not provide enough forage to supply needed energy, or enough protein and phosphorus for the animal to make efficient use of the available energy, and it may cause the animals to switch to watery green forage of low dry-matter content as soon as it appears (Dietz 1965).

Dietz (1965) summarized several nutritional studies on deer ranges in Colorado, as follows: (1) clipping intensity did not affect nutritional value of plants, (2) plants were generally higher in nutrients during the growing season than during the dormant season, (3) the leaves of plants contained higher percentages of nutrients than the stems, (4) summer range plants were generally more nutritious than winter range plants, (5) browse species were more completely digested by deer when fed alone than in mixtures, and (6) there were no significant differences among experimental deer in their ability to digest the nutrients of browse species.

Important shrub and grass species were generally highest in protein, carotene, ash, calcium, and phosphorus in early summer and decreased until early spring. Crude fat, fiber, and nitrogen-free extract percentages generally increased as plant development advanced toward winter dormancy (Dietz 1965).

Evergreen and semi-evergreen species, such as juniper, big sagebrush, rabbitbrush, and bitterbrush generally maintain higher nutrient levels than the deciduous plants. On a Colorado winter range, big sagebrush and rubber rabbitbrush were the best sources of protein, and these plus Rocky Mountain juniper were highest in phosphorus during the winter period. On summer range, quaking aspen and a willow (Salix subcoerulea) were the best sources of these two constituents during the growing season. Big sagebrush had a higher digestion coefficient and more TDN than bitterbrush and mountain mahogany (Dietz 1965).

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Short et al (1966) reported on nutrient analyses of selected deciduous and evergreen shrubs in Colorado. Bitterbrush, a deciduous species, had high spring and summer values for protein, carotene, ash, phosphorus, and other nutrient elements. It had high autumn and winter levels for dry matter, crude fat, and caloric (energy) content. Juniper, an evergreen species, had less pronounced seasonal changes. It had a higher caloric content than bitterbrush at all seasons. This pattern was observed in other species tested. The highest protein content was generally in spring (e.g., juniper 8, willow 15, aspen 17 percent), except bitterbrush was highest in summer. Most species retained high protein levels in summer, contained 6-10 percent protein in autumn, and 6-7 percent in winter. Juniper had the least seasonal variation, willow and aspen had the greatest. Fat content and caloric energy were highest in autumn and declined in spring. Winter fat content of mahogany, bitterbrush, and willow ranged from 4-6 percent, sagebrush was 12 percent, and aspen, rabbitbrush, and juniper were 15-19 percent.

Grass, when green, is high in water, protein, and mineral content, and low in crude fiber. As grasses mature, they lose much protein and mineral content and energy value. Dry grass, of high fiber and low digestibility, furnished little more than the maintenance requirement. Deer prefer green grass that is free of stubble, and utilize grazed pastures in preference to those in which old stubble remains. Deer leave grass for forbs as they appear. Later, developing new shrub growth becomes important (Dasmann 1971).

Chaparral burning does not invariably produce a dramatic increase in the health and productivity of resident deer. Indiscriminate burning of mixed stands of chaparral tends to favor development of unpalatable species because of heavy grazing pressure on favored species regrowth. Mature brush provides good cover, although it is not too good for forage. Chaparral brush species have low protein content during the August to April dormant period. These species are adapted to fire. Regrowth, following fire, has a higher protein content, the effects lasting about three years. A better diet is available in the oak-woodland type where, when available, deer utilize green grass and forbs in fall, winter, and spring, and acorns in late summer, fall, and winter. Brush burning does not favor acorn production. The most serious dietary deficiency in oak-woodland is energy intake during the winter, in poor acorn crop years, when grass is the principal forage (Longhurst 1969).

On a poor condition pinyon-juniper-shrub range in the Guadalupe Mountains of New Mexico, deer existed on poor quality woody species, such as: Quercus undulata, juniper, and yucca species (based on 93 rumen samples taken over a four-year period). These plants were inadequate in protein and phosphorus, and deer were in poor condition. In a year following heavy precipitation, forbs became especially abundant, and stomach samples indicated the yearlong deer diet changed to forbs and the deer were in better condition (Anderson et al 1965).

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Boeker et al (1972), making rumen analyses from deer in the pinyon-juniper type of southwestern New Mexico, found protein intake ranged from 9 to 12 percent seasonally. It was highest in winter, lowest in summer and fall. Birchleaf mountain mahogany and oak species comprised more than half the diet and were adequate nutritionally to sustain deer during all seasons.

Swank (1956), in the southwest, found protein content to be almost twice as high in growing plants as in dormant ones. The most preferred plants maintained the highest protein levels (Table 5).

Table 5. Percent Protein Content of Browse in Northern Arizona. (Swank 1956)

Species	April	July	January	Preference
Mountain mahogany	14.1	7.2	10.9	Most
Desert ceanothus	14.3	8.2	8.8	Most
Cliffrose	10.9	11.6	8.4	Most
Hollyleaf buckthorn	16.3	7.3	6.5	High
Utah juniper	—	5.6	4.9	Low
Manzanita (A. pungens)	8.1	5.5	6.6	Low
Manzanita (A. pringlei)	—	4.9	5.7	Low
Turbinella oak	10.1	7.3	9.0	Low

Coffeebush, one of the most valuable desert shrubs, also had high protein content, ranging from 9.4-21.1 percent. The phosphorus content of plants tested was only sufficient during the growing season.

In central Arizona chaparral, shrubs are usually deficient in phosphorus, especially from November through April, but winter-growing forbs compensate for it (Urness et al 1971).

Table 6. Phosphorus Content in Percent. (USDA, Forest Research Highlights, 1970)

	Forbs	Browse
October	.22	.19
January	.43	.14
February - April	.40	.23

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Table 7 shows the analysis of the percent protein content of key browse species on a poor-condition winter range in northeastern California.

Table 7. Percent Protein Content of Key Browse Species in Northeastern California. (Interstate Committee 1954)

Species	November	January	March
Bitterbrush	9.2	7.3	4.5
Sagebrush	10.0	9.1	6.2
Juniper	7.8	5.6	6.9

Tests in California by Leopold et al (1951) indicated that the content of crude protein approximately follows the gradient of shrub palatability.

Table 8. Crude Protein - Palatability Relationship. (Leopold et al 1951)

Summer Range	Average Percent Crude Protein	Observed Palatability
Ceanothus cordulatus	16.1	Most preferred
Prunus emarginata	15.2	Important
Winter Range		
Cercocarpus betuloides	13.4	High
Ceanothus integerrimus	10.0	High
Ceanothus cuneatus	9.9	High
Chamaebatia foliolosa	8.7	Less
Arctostaphylos patula	7.5	Less
Arctostaphylos mariposa	4.7	Unpalatable

The seasonal variation of protein content in Ceanothus cuneatus was:

Month -	October	December	February	April
Percent -	11.4	8.6	8.4	10.3

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Table 9. Percent Protein Content of Selected Browse Plants in Nevada.

Species *	Sep	Dec	Mar	May	Jul
		Fox Mt. (Deibert 1968)			
Cele	9.2	9.5	6.3	7.1	12.9
Putr	3.3	12.9	7.9	10.7	13.8
Amal	2.7	6.4	6.9	5.3	12.4
Artr	7.6	8.2	8.2	11.0	14.4
Prvi	7.1	6.5	8.2	20.8	13.9
Sylo	8.5	-	-	3.9	12.2
Juos	7.5	7.5	7.1	5.0	9.0
		Ruby Butte (Delmas 1971)			
Amal	8.5	5.6	6.8	25.5	11.0
Artr	11.8	10.5	14.0	15.0	16.3
Cele	10.2	9.1	8.9	10.3	12.8
Juos	5.2	7.9	6.1	6.4	9.2
Pimo	7.2	9.4	7.9	8.7	8.1
Potr-1	12.6	6.8	6.2	7.2	15.3
Prvi	10.5	6.8	9.3	30.1	17.4
Putr	9.7	7.5	9.9	11.3	12.6
Sylo	7.2	3.9	5.5	3.4	11.1
Grasses	9.6	2.7	3.4	21.3	11.1
Forbs	6.8	-	-	24.3	17.0

* See plant reference list for plant symbols.

(2) Digestibility depends generally on two factors: available nutrients which promote bacterial growth (such as carbohydrates), and proteins that are balanced against the content of chemicals which inhibit bacterial growth or are actually bactericidal. Deer can digest the latter in small amounts if mixed with other forage. Highly aromatic plants are likely to be most inhibitory. Digestibility and palatability are directly related.

Table 10. In vitro Digestibility of Various, Principally Woody, Plants by Deer Rumen Bacteria. (Longhurst et al 1968)

Group	Crude Protein	Relative Digestibility
Alfalfa *	16.1	100%
Most palatable	10.9	83
Unpalatable	10.0	45

* Standard for comparison

In vitro tests indicated that deer seemed to be better equipped to digest browse than grasses; whereas the reverse is true with domestic sheep. In vitro digestion trials run on several native and introduced grasses using the rumen fluid from both deer and sheep showed the introduced perennials (orchard and Harding grass) to be more digestible than native perennials (squirreltail, Idaho fescue, and several needlegrasses). All species tested were more digestible in sheep than in deer rumen fluid (Longhurst et al 1968).

Total digestible nutrients (TDN) is closely related to digestible energy. TDN is based on the digestibility of: protein, fat, fiber, nitrogen-free extract, and ash (Dietz 1965). The percent of TDN for an adequate daily ration for cattle is 50 to 63 percent of the total feed eaten.

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Dietz et al (1962) conducted digestibility trials on three browse species, plus alfalfa, during the winter season in Colorado. Alfalfa pellets were far superior to browse species in crude protein (Table 11). Sagebrush had higher percentages of digestible protein, fat, and fiber, and more TDN with a better nutritive ratio than the deciduous mountain mahogany or bitterbrush. Mountain mahogany had higher digestion coefficients than bitterbrush for protein, fat, and fiber, lower for nitrogen-free extract, and equal in TDN. Bitterbrush and alfalfa were considerably more palatable to deer than mountain mahogany or sagebrush. Sagebrush palatability was low. It was indicated that addition of alfalfa to a browse ration inhibited the digestibility of individual nutrients and lowered the total digestible nutrients. Deer digested almost 40 percent of the crude fiber in sagebrush. Addition of alfalfa pellets to bitterbrush greatly inhibited the digestibility of the combined fats; this was also true to a lesser extent in mahogany. Of the three browse species tested, it appears that either bitterbrush or mountain mahogany could provide the essential nutrients for deer, at least for brief periods. Deer would only eat sagebrush in mixtures.

Table 11. Digestibility of Two Important Browse Species. (Dietz et al 1962)

Chemical Analysis	Protein	Crude Fat	
	Percent		
Purshia tridentata	8.70	7.51	
Cerocarpus montanus	7.67	4.01	
Alfalfa	16.01	2.97	
Digestion Coefficients	**Protein**	**Crude Fat**	**TDN**
	Percent		**Lbs/Cwt**
Purshia tridentata	30.66	44.35	52.53
Cercocarpus montanus	42.85	54.35	52.67

Chemical analysis of big sagebrush showed it to be half as high in digestible protein and twice as high in digestible fats and carbohydrates as green alfalfa. The digestible nutrient content is well above the minimum for domestic ruminants. Six penned mule deer having a choice of big sagebrush and black sagebrush preferred black sagebrush, but none thrived on the diet. Only two bucks ate any quantity - averaging 2.1 and 2.8 pounds per day - and they lost 6.5 and 9 pounds in a 3 and 4 week period (Smith, A. D., 1950b).

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Palatability of plants can vary with site conditions. Preferences for individual browse species may change markedly in different areas. Utilization of forage is not usually in proportion to its abundance, but, of course, choice of forage is limited to what is available. Deer apparently are able to select plants high in nutrient content. Unpalatable plants often contain high levels of nutrients. Deer may prefer or avoid individual plants of a species. Smith (1950a), for example, observed that deer avoided individual junipers which had a particularly high concentration of volatile oils. Soil fertility has long been known to influence palatability of forage plants. Deer can distinguish fertilized plants. Studies at Hopland Field Station, California, on winter utilization of herbaceous forage, over a four-year period, indicated deer consumed an average of 1143 pounds per acre from plots fertilized with nitrogen and phosphorus as contrasted with 282 pounds from unfertilized plots (Longhurst et al 1968).

Swank (1956), in the southwest, found a direct relationship between plant moisture content and palatability. Moisture content, in general, was highest at the peak of growth and declined to a low in the dormant period. Moisture content of actively growing plants was higher on burned or railed sites than on undisturbed sites, and use was concentrated on them at that time. There was no difference during the dormant season.

On disturbed sites, during periods of high moisture content, seldom-used shrub species received considerable browsing. Some species, as manzanita, were exceptions. Burning increased protein content, but plants from burned areas were lower in phosphorus. Deer use on a burn far exceeded use on an adjacent area (Swank 1958).

McCulloch (1969) observed on wildfire burns in Arizona pinyon-juniper that for the first four years following burning most of the normally unpalatable species are very palatable. For up to seven years, deer prefer the sprouts from burned shrubs to the same species unburned. More deer and cattle were supported on burns than on non-burns. Railed brush sprouts were more palatable to deer than before treatment, but less palatable than after burning.

Swank (1958) reported that high deer populations are found, in Arizona chaparral, in the mixed shrub type dominated by turbinella oak but containing such palatable species as mountain mahogany, desert ceanothus, and hollyleaf buckthorn; and to the north and at higher elevations, cliffrose. Low populations were found in the turbinella oak-skunkbush type where few other shrub species occurred.

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Taste responses by pen-raised, black-tailed deer were studied at Oregon State University for possible application in the development of attractants or repellents. The test consisted of two containers, one with a water solution of the test substance, one containing only water. Deer showed definite preferences for sweet, sour, and bitter tastes in that order, and no preference for salt. Glucose was still highly preferred at a 20 percent concentration - the highest tested, and sucrose up to 10 percent solution. Differences in odor appeared to have considerable effect on responses to all of the sour-tasting solutions. Acetic acid was preferred, but not hydrochloric. Bucks demonstrated a marked preference for bitter solutions (as quinine sulfate) whereas does rejected them. Bucks showed some preference for sodium acetate at low concentrations, but both sexes rejected sodium chloride even at low concentrations. In other tests, goats preferred sweet, salt, sour, bitter; cattle: sweet, sour; and sheep only responded to relatively high concentrations of sugars. Deer ranked between goats and cattle in taste sensitivity (Crawford and Church 1971).

Ruminants depend almost entirely upon rumen microorganisms for proper digestion of food. Mule deer rumen microbial populations from animals in the natural habitat in Utah, and from captive deer fed various rations, were studied by Pearson (1969). Preliminary comparison of mule deer and domestic animal rumen bacteria showed no important morphological differences. Rumen samples contained 13 identifiable types of bacteria and one genus of ciliate protozoa. All 13 bacterial types were observed in most of the sampled animals. Captive deer on alfalfa hay, plus barley, had the highest total count of bacteria, followed by bitterbrush, curl-leaf mountain mahogany, and alfalfa. It is known that two or three times more bacteria are present when concentrates are fed to cattle. An apparent individual bacterial specificity for a particular kind of diet or nutrient was indicated. Adverse conditions could cause specific bacteria to disappear from the rumen, thus preventing digestion of a particular nutrient. This may occur in even 3 or 4 days of starvation. Numbers of individual types of bacteria showed seasonal fluctuations in rumen from deer in the natural habitat. This probably reflected changes in the diet or in its nutritive value during the seasons. Animal age was not a factor. More ciliate protozoa were found when captive deer had salt added to their alfalfa hay diet. It was suggested that the quantity of ciliate protozoa in the rumen could be used to indicate feeding conditions of the deer. Protozoa are more sensitive to feeding conditions than bacteria. Similar responses have been reported in domestic animals. In free-ranging deer the rumen protozoa decreased with plant maturity and with food shortage. Protozoa in deer apparently digest starch, increase available energy and fermentation rate.

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Rumen microorganisms of wild deer on a normal browse diet are capable of digesting alfalfa hay. They could obtain the same amount of energy from hay as cattle or sheep. No major adjustments in the microbial spectrum appear to be necessary when an animal changes from a browse diet to a diet of alfalfa hay. Microbial activity of deer fed a starvation diet of sagebrush indicates a loss of properly functioning microorganisms - either dead or inactive (Nagy et al 1967).

Trials by Nagy et al (1969) showed that both crude fiber levels and crude protein levels affected food intake. Three groups of deer were fed three types of hay for 21 days (Table 12).

Table 12. Crude Fiber and Protein Levels Affect Food Intake. (Nagy et al 1969)

	Crude Fiber %	Crude Protein %	Aver. Daily Food Intake g/kg	Aver. wt. Loss %
Good quality alfalfa	27.0	18.0	10.3	3.2
Poor quality alfalfa	42.0	16.4	5.1	6.8
Native hay	31.1	4.5	4.7	7.9

The poor quality hay had adequate protein but very high crude fiber (42%). The native hay had a crude fiber level comparable to good hay, but was deficient in protein (4.5%). Further studies indicated that deer can handle high fiber diets if its physical form is appropriate and if the diet is adequate in other nutrients.

Volatile or essential oils may inhibit growth of rumen bacteria. Deer avoid plants containing such substances. They depend largely upon sense of smell, and secondly upon taste and sight. Effects of aromatic and phenolic compounds vary; some are only transitionally present. Deer avoid plants containing systemic toxins, such as alkaloids or glucocides (Longhurst et al 1969).

Powell (1969, 1970) found high oil content (6 percent air-dry weight) in big sagebrush growing under the most favorable conditions: tall vigorous plants on deep loam soil with a low lime content. Short sagebrush plants on shallow, highly calcareous rocky soil had a low oil content (3.5 percent). Oil content was greater in September (4.7 percent) than in February (2.4 percent) or April (2.6 percent). Volatile oil content increased as sagebrush size increased. There was a strong inverse correlation between magnesium (and phosphorus) in the soil A horizon and volatile oil content.

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c. Composition.

(1) Selection. Deer preferences change with the seasons of the year, the growth stage of plants, and other factors. Smith (1953), feeding two captive deer, noted differences in their preferences; one deer was less selective, ate more forbs of more species. Study by Pudney (1972), in Nevada, indicated that utilization of common serviceberry, cliffrose, chokecherry, and forbs was closely related to their availability. As winter progresses, deer turn to sagebrush more and more (Paez 1967). Three species probably provide the bulk of the forage for deer on Utah winter ranges: sagebrush, juniper, and scrub oak (Q. gambelii). Other plants are more preferred, but these three are available (Smith 1959). Berg (1966), in Nevada, found that whenever bitterbrush occured in a plant community, that area invariably ranked among the highest in deer use, whereas stands of pure sagebrush rated poorly. On summer range, communities rich in forbs were heavily used. Boeker et al (1972) found that selection of forbs was not controlled entirely by availability. Preference for individual forb species could not be explained by measured differences in chemical composition or digestibility. In general, forb species high in moisture and crude protein were preferred.

Table 13, condensed from Edgerton and Smith's (1971) three-year study of forage use compared to availability, shows definite selectivity and high preference for particular species. Numerous items of limited availability occurred in the diet at much higher percentages than would be expected if not taken selectively.

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Table 13. Seasonal Forage Availability and Use by Deer and Elk, in Percent. Northeastern Oregon. (Edgerton and Smith, 1971)

Species	Grassland Diet	Grassland Avail.	Open Forest Diet	Open Forest Avail.	Dense Forest Diet	Dense Forest Avail.
			SPRING			
Carex geyeri			30	29		
ALL GRASSES	9	41	32	50	2	4
Arnica cordifolia			17	10		
Camassia quamash	38	6				
Lomatium leptocarpum	14	11				
ALL FORBS	91	59	46	38	3	41
Symphoricarpus albus			12	3		
Vaccinium membranaceum					14	7
Vaccinium scoparium					72	18
ALL SHRUBS	-	0	22	12	95	55
			SUMMER			
Carex geyeri			62	46		
Danthonia unispicata	16	28				
Sitanion hystrix	20	1				
ALL GRASSES	44	37	64	72	5	6
Adenocaulon bicolor					9	1
Sidalcea oregana	40	1				
ALL FORBS	56	63	13	14	13	41
Spiraea betulifolia			8	3		
Symphoricarpus albus			8	4		
Vaccinium membranaceum					20	5
Vaccinum scoparium					42	16
ALL SHRUBS	-	0	23	14	82	53
			FALL			
Agropyron spicatum	10	3				
Carex geyeri			50	46		
Danthonia unispicata	24	27				
Koeleria cristata	26	3				
Poa secunda	34	4				
ALL GRASSES	98	39	59	72	2	6
ALL FORBS	2	61	-	14	5	41
Chimaphila umbellata					8	18
Pachystima myrsinites					33	5
Spiraea betulifolia			15	3		
Symphoricarpos albus			22	4		
Vaccinium membranaceum					20	5
Vaccinium scoparium					26	16
ALL SHRUBS	-	0	41	14	93	53

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Table 14 compiled from data reported by Trout and Thiessen (1968) compares the principal food items identified in deer stomachs with the vegetation available on a severely overutilized summer and winter herd range in Owyhee County, Idaho. Deer relied upon western juniper and sagebrush, the principal species available, during January and February and their physical condition declined rapidly. Bitterbrush received heavy use throughout the year. Grass was most important in March (64%), April (75%), and May (57%).

Table 14. Comparison of Percent Composition of Vegetation and Utilization of Some Principal Food Items in Deer Diet. Southwestern Idaho. (Trout and Thiessen 1968)

	Composition (%)		Deer Diet (% of Volume)						
Food Items	Winter Range	Summer Range	Nov	Dec	Jan	Feb	Mar	Jul	Aug
Juniperus occidentalis	17.0	27.7	7	28	21	38	17	1	4
Cercocarpus ledifolius	-	0.6	12	24	-	-	-	4	3
Purshia tridentata	6.8	1.3	19	T	15	35	3	13	22
Artemisia tridentata	11.8	27.6	7	9	33	13	5	T	-
Artemisia arbuscula	24.4	1.2	2	-	7	11	5	-	-
Ceanothus velutinus	-	8.0	2	11	-	-	-	37	15
Shrubs	63.2	81.0	72	85	76	97	30	88	79
Forbs	6.7	8.2	15	6	7	2	5	8	10
Grasses	28.6	8.5	8	7	7	T	64	T	5

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(2) Variety. Deer eat many kinds of plants, but at any one time and place their diet usually consists largely of only a few species. Many plants occur with high frequency, but in trace amounts. Dixon (1934) stated that over 200 kinds of plants were utilized for food by mule deer of California. On a range in Utah, 125 plant species were utilized, but 8 species comprised most of the diet (J. Smith 1952). Richens (1967), in Utah, showed that at least 34 woody species and 14 forbs were eaten by deer on the Uinta Mountains. In northeastern Oregon, use was recorded on 73 species: 15 grass and grass-like, 46 forbs, and 12 shrubs, but 5 species made up more than half the diet (Edgerton and Smith 1971). Analysis of 59 deer stomachs collected in winter from ten national forests in the northern Rocky Mountain area showed 82 different forage species had been utilized by deer (De Nio 1938). In New Mexico, Boeker et al (1972) analyzed 77 rumen and found 25 food items in volumes greater than 0.1 percent and 13 additional items at trace levels. They found only three species present in volumes greater than five percent of the diet. Also in New Mexico, Anderson et al (1965) analyzed 93 rumen, found 97 food items of which five made up approximately two-thirds of the total diets. Edgerton and Smith (1971), in eastern Oregon, recorded use by deer on 73 species, but five species made up more than half the overall total diet. Mackie (1970) made more than forty thousand observations of deer feeding in eastern Montana over a four-year period. Table 15 summarizes a comparison of the number of species utilized and the number of species providing one percent or more of the total diet.

Table 15. Observed Forage Utilization. Number of Species Used, by Season. Montana. (Mackie 1970)

	Summer		Fall		Winter		Spring	
	Number of species used							
	Total	1%	Total	1%	Total	1%	Total	1%
Grass	6	0	8	1	9	1	7	2
Forbs	44	5	33	5	14	4	44	9
Shrubs	12	4	12	9	16	10	16	10
Total	62	9	53	15	39	15	67	21

(3) Feeding Observations. Smith and Hubbard (1954) feeding captive deer found no relation between time spent feeding on a species and the amount of feed obtained from it. Volume consumed was a better index of diet and importance of a plant.

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Richens (1967), studying winter range in the Uinta Mountains, found big sagebrush and two mountain mahogany species (C. montanus and C. ledifolius) to be key species. Bitterbrush and serviceberry were important. Utah juniper and pinyon pine provided emergency food and cover. Important forbs in the spring season were: Salsola kali, Medicago sativa, Astragalus sp., Rumex crispus, and Delphinium nelsoni. Deer also fed on new spring growth of Chrysothamnus viscidiflorus, Ephedra viridis, and Sarcobatus vermiculatus.

Julander (1966) listed preferred forb species utilized by deer in the mountains of Utah as: Geranium richardsoni, Thalictrum fendleri, Wyethia amplexicaulis, Aster engelmanni, Heracleum lanatum, and Trifolium. Sambucus and Populus tremuloides were preferred shrubs.

Smith (1959) fed captive deer for three winters and found weight losses were greatest in animals on sagebrush or juniper diets and somewhat less on oak. These three species provided the bulk of the forage on northern Utah winter ranges. Juveniles were less able to survive diets of restricted species composition even when the amount of feed available was not limited. Smith (1950a) found that consumption of big sagebrush increased greatly late in winter, and deer fed on it moderately even when other species were available. Smith (1953) fed two deer through two summers, offering forbs and shrubs. Dry weight of herbs consumed exceeded that of browse only during May. During the wetter year, forbs amounted to more than 15 percent of the diet. Forbs used early were: mule's ear, alfalfa, storksbill, sweetclover, and locoweed. Important later in the summer were: mule's ear, dogbane, geranium, dandelion, aster, Chinese lettuce, skunkflower, and black medic. Browse species important during summer included willow, serviceberry, snowbrush, curlleaf mountain mahogany, and cliffrose. Species available but practically not eaten were alder, rabbitbrush, buffaloberry, sagebrush, and juniper.

Mackie (1970), in eastern Montana, noted that yellow sweetclover comprised nearly one-half of all feeding observations during the summer; heavy use commenced after flowering and continued into fall (Table 16). Skunkbush ranked second in summer and remained important along with snowberry in timber types during the fall. Rubber rabbitbrush, after flowering, may have ranked first in importance during October and November. Big sagebrush, rubber rabbitbrush, and juniper were taken most frequently during winter cold and heavy snow. Grasses and forbs were predominant in spring and were most used in wet years. Winter use of rabbitbrush greatly increased in wet years.

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Table 16. Observed Utilization of Principal Forage Plants. Eight Vegetation Types. Four Years. Percent of Total Diet by Season. Montana. (Mackie 1970)

Species	Summer	Fall	Winter	Spring
Grass				
Poa secunda	T	6	2	10
Total	T	6	2	13
Forbs				
Allium textile				6
Lomatium foeniculaceum				5
Melilotus officinalis	45	14	3	2
Total	56	26	10	35
Shrubs				
Artemisia longifolia	T	10	3	T
Artemisia tridentata		5	33	24
Chrysothamnus nauseosus	T	9	11	1
Chrysothamnus viscidiflorus	T	15	8	2
Juniperus scopulorum		3	10	9
Rhus trilobata	25	15	5	4
Rosa sp.	5	2	T	2
Symphoricarpos sp.	9	13	7	4
Total	43	74	87	52

Halloran and Kennedy (1949) found the following plants to be important deer forage in the San Andres Mountains of southern New Mexico:

Garrya wrightii	yearlong, especially winter
Cercocarpus breviflorus	yearlong, especially winter
Dasylirion wheeleri	March to July
Fendlera rupicola	February-March
Sphaeralcea incana	March to August
Opuntia species	June to December
Yucca baccata	March to June
Agave parryi	June to August

Lamb (1971) stated that deer are less dependent upon sagebrush in New Mexico than in deep snow country. Winterfat received little use. Preferred species were bitterbrush, mountain mahogany, oaks, and skunkbush.

Lang (1957) listed major forage shrub species in New Mexico as mountain mahogany, gambel oak, sagebrush, fendlerbush, and bitterbrush. The desert subspecies of mule deer primarily ate browse, especially wavyleaf oak, yucca, juniper, skunkbush, and lichens.

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In the Ruby Mountains of northeastern Nevada, Depaoli and Tueller (1970) found the following woody species to be most used on the winter range.

Most frequently used	Most heavily used
Chrysothamnus viscidiflorus	Cercocarpus ledifolius
Artemisia tridentata	Purshia tridentata
Purshia tridentata	Amelanchier alnifolia
Tetradymia canescens	Sambucus glauca
Symphoricarpos longiflorus	Prunus virginiana

Swank (1958) reported on deer browse plants in the Arizona chaparral. Preferred species were: Cercocarpus montanus, Ceanothus greggii, Rhamnus crocea, and Cowania mexicana. Garrya wrightii received moderate use. Available species lightly utilized included: Quercus turbinella, Rhus trilobata, Arctostaphylos pungens, Rhus ovata, and Quercus emoryi.

Hungerford (1965) observed deer forage preferences on disturbed and reseeded forest and meadow sites of the Kaibab Plateau. These disturbed areas produced the most food and were preferred by the deer to natural undisturbed areas. Reseedings were very attractive to deer. They preferred early growth of orchard grass, June grass, and wheatgrasses, and also utilized clovers and dandelion. Aspen, especially the leaves, became more palatable as the summer progressed. Mountain dandelion, sweetclover, buttercup, daisy, and a few other forbs were important.

According to Longhurst et al (1952), preferred browse on the west slope of the Sierras is Ceanothus cuneatus, Ceanothus integerrimus, and Cercocarpus betuloides, and about a dozen other species of importance. On the Great Basin ranges Purshia tridentata and Cercocarpus ledifolius are preferred and widespread. Ceanothus prostratus and Prunus subcordata are preferred, but of limited distribution. Sagebrush and juniper are abundant, less palatable, but much used.

Observations of Dixon (1934) in Yosemite indicated the most important species in summer were Lotus americanus, Polygonum aviculare, Festuca elatior, Prunus virginiana, Quercus kelloggii, Ceanothus integerrimus, and Holcus lanatus. New green grass was eaten whenever available, especially in April and May. Also taken when available were mistletoe, lichens, mosses, mushrooms, acorns, and berries. Many weeds were eaten in the fall, also: Carex, Prunus, Amelanchier, various oaks (leaves and acorns), bitterbrush, and deerbrush. Wedgeleaf ceanothus was important in winter, along with green manzanita, and scrub oak. Annual grasses became important in spring.

The California and southern races of deer in California eat green annual grasses in winter. Burro deer utilize honey mesquite, palo verde, ironwood, catclaw, and mistletoe in winter (Dixon 1934).

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In California, Leopold et al (1951), studying the Jawbone deer herd near Yosemite, recorded feeding sight records and stomach content analyses. Grasses and forbs were of little importance except during late winter and spring. On the summer range, Ceanothus cordulatus was the one plant most often associated with the highest concentrations of deer. Table 17 lists the principal forage species recorded for the summer and winter seasons.

Table 17. Principal Forage Species of the Jawbone Deer Herd on the West Slope of the Sierras. Data in percent. (Leopold et al 1951)

Summer			
Sight records (2 years)		Stomach Analysis (16 deer)	
Ceanothus cordulatus	47	Ceanothus cordulatus	31
Populus tremuloides	15	Quercus Kelloggii	16
Quercus vaccinifolia	10	Ceanothus integerrimus	13
Ceanothus integerrimus	6	Quercus vaccinifolia	13
Salix sp.	5	Chamaebatia foliolosa	7

Winter		(24 deer)	
		Volume	Frequency
Ceanothus cuneatus	51	12	63
Chamaebatia foliolosa	25	37	75
Quercus Kelloggii	13		
Quercus sp.		14	63
Arctostaphylos sp.	9	11	67
Forbs and grasses		14	92

(4) Stomach Analyses. The analysis of contents of deer stomachs yields much specific information on the feeding habits of these animals. It is necessary, however, to consider the differential in the rate of digestion of succulent materials such as fleshy fruits and green leaves versus dry, woody stems. Since herbaceous forage is generally more easily digested than browse, it is probable that grass and forbs are more important in the deer diet than stomach analyses indicate (Interstate Committee 1951).

In Montana, Wilkins (1957) analyzed 27 stomach samples from deer collected in the Bridger Mountains at various seasons (Table 18).

Table 18. Stomach Analysis Summary by Major Food Categories of 27 Deer From Bridger Mountains, Montana. (Wilkins 1957)

Season	Number	Grass	Forbs	Browse
		Volume in percent		
Spring	4	37	40	24
Summer	6	3	77	19
Fall	6	3	24	73
Winter	11	14	18	66

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Wilkins found the principal species in the summer sample to be Tragopogon dubius, Balsamorrhiza sagittata, Aster modestus, Taraxacum officinale, Lupinus argentea, Purshia tridentata, and Vaccinium species. In the fall, bitterbrush and western snowberry were most important. Sagebrush first occurred in mid-October samples. In winter, bitterbrush use declined and sagebrush increased to become 25 percent of the diet. Use of grass was important in spring during the initial green-up.

In the Owyhee country of southwestern Idaho, Trout and Thiessen (1968) collected 123 deer stomachs over a three-year period (1964-66), representing every month of the year. Both summer and winter ranges are described as in deteriorated condition with livestock competition apparent. Table 19 indicates the diet of these deer (often in poor condition) where preferred forage is severaly limited. Consult Table 14 for comparison with range composition.

Table 19. Principal Food Items Identified in 123 Deer Stomachs Collected in Southwestern Idaho. (Trout and Thiessen 1968)

Season *	Winter	Spring	Summer	Fall
No. of Deer	31	30	34	28
Food Items	Range in monthly values Percent of volume			
Shrubs and trees				
Juniperus occidentalis	21-38	7-17	1-4	2-7
Cercocarpus ledifolius	0-24	-	3-6	5-12
Populus tremuloides	-	-	0-5	5-21
Prunus virginiana	-	-	6-9	1-12
Prunus emarginata	-	-	0-9	1-18
Purshia tridentata	T-35	T-4	1-22	5-19
Artemisia tridentata	9-33	4-5	0-3	T-11
Artemisia arbuscula	0-11	1-5	-	-
Ceanothus velutinus	0-11	-	8-37	2-14
Symphoricarpos vaccinoides	-	-	5-22	T-12
Berberis nervosa	0-11	-	-	-
Forbs				
Balsamorhiza sagittata	0-5	-	-	T-5
Eriogonum sp.	-	1-10	-	-
Phlox sp.	-	T-3	0-6	0-3
Agoseris sp.	-	0-7	-	-
Grasses	T-7	57-75	T-15	2-11

* Three months each, beginning with December.

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In Oregon, Maw et al (1963) analyzed forage content of stomachs from deer collected on the Silver Lake range in October. There was a considerable difference between years in the utilization of several palatable browse species and especially in the use of grass (Table 20).

Table 20. Rumen Analysis of Deer From the Silver Lake Herd, Oregon, Collected in October. Data in percent. (Maw et al 1963)

	1958		1959	
	17 deer		20 deer	
Food Items	Vol.	Freq.	Vol.	Freq.
Purshia tridentata	61.6	100	35.2	60
Cercocarpus ledifolius	10.9	53	T	25
Ceanothus velutinus	10.5	53	9.5	45
Berberis repens	9.0	29	0.8	40
Arctostaphylos patula	0.8	41	1.6	25
Populus tremuloides	-	-	13.0	35
Artemisia tridentata	T	12	4.4	50
Juniperus occidentalis	T	35	3.5	20
Pinus ponderosa	T	71	T	75
Gramineae	T	65	11.7	85
Mushrooms	5.0	71	3.5	60
Lichens	1.7	53	7.6	70

Anderson et al (1965), working on pinyon-juniper range in southeastern New Mexico, analyzed 93 stomachs and found 53 food items in volumes of one percent or more per individual sample, over a 4-year period. The following principal items comprised nearly two-thirds of the total analysis.

Quercus undulata	spring, summer, fall
Juniperus species	winter, summer, fall
Cercocarpus breviflorus	winter, fall
Yucca species	winter, spring
Unidentified forbs	spring, summer, fall

Boeker et al (1972) studied mule deer food habits in southwestern New Mexico where the overstory vegetation composition was about 60 percent Pinus edulis and Juniperus deppeana, 30 percent oaks, and 9 percent Juniperus osteosperma. Shrub composition was: Cercocarpus breviflorus 52, Garrya wrightii 22, and Rhus trilobata 18 percent. Analysis of 77 rumen samples collected over a 6-year period (half of them in the fall) revealed 25 identified food items in volumes greater than 0.1 percent per sample, plus 13 at trace level (Table 21). Utilization of browse varied from 58 percent of the diet in spring and summer to 94 percent in winter. Rumen composition in the fall consisted of up to 45 percent birchleaf mountain mahogany.

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Table 21. Food Items by Estimated Percent Volume in Rumens of 77 Mule Deer. New Mexico, 1964-1969. (Boeker et al 1972)

	Volume (%)
Birchleaf mountain mahogany	32.9
Oaks	23.6
Junipers	5.2
Wright silktassel	4.3
Skunkbush sumac	3.4
Cholla cactus	2.1
American mistletoe	1.5
Total for 9 woody species: 74.5	
Dalea	3.3
James bundleflower	3.3
Birdbill dayflower	2.8
Pinnate tansymustard	1.7
Obtuse tansymustard	1.6
Buffalogourd	1.0
Total for 15 forb species: 16.1	
Grasses total	2.2
Unidentified	7.2

Reynolds et al (1970) reported on several Game Department studies showing rumen content averaging 8 to 10 percent foliage and 20 to 25 percent acorns (fall season) of gambel oak in northern Arizona pine forests.

Swank (1958) collected 24 rumen samples in Arizona chaparral during January to May. The principal plants present in frequency and bulk in order of importance were: Ceanothus greggii, Rhamnus crocea, Juniperus sp., Cercocarpus montanus, Quercus turbinella, and Artemisia sp.

McCulloch (1969) studied deer food habits on a pinyon-juniper burn in northern Arizona. Abundant forbs and seeded grasses were available, but few live woody plants were present 13 to 15 years after the burn. In the fall, 85 percent of the rumen content of deer collected on the burn was non-woody, from outside the burn it was 40 percent (Table 22). Seeded wheatgrasses were notable fall food on the burn, where it remained green most of the winter. Cliffrose, a key species on the Kaibab, was scarce, with regrowth severely hedged on the burn.

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Table 22. Average Contents of Mule Deer Rumen. Fall Collection in Northern Arizona Pinyon-Juniper Type. (McCulloch 1969)

Species	Volume (%)		Frequency (%)	
	Burned	Unburned	Burned	Unburned
Sample size:	8	9	8	9
Agropyron spp.	20	1	100	11
Bromus tectorum	8	1	100	44
Grasses total	33	7	100	100
Penstemon linarioides	21	7	88	78
Sphaeralcea spp.	8	3	50	33
Eriogonum spp.	7	3	75	56
Cirsium spp.	6	Tr	38	11
Lupinus spp.	1	6	13	56
Forbs total	52	33	100	100
Juniperus osteosperma	6	16	75	89
Artemisia tridentata	6	11	75	100
Cowania mexicana	1	8	50	67
Quercus gambelii (mast)	Tr	16	13	44
Shrub & tree total	15	60	100	100

Longhurst (1969) reported on the effects of chaparral vegetation manipulation on deer food habits. Controlled burning occurred during four years on Cow Mountain south of Ukiah. As shown in Table 23, the diet of deer inhabiting the oak-woodland type at the lower elevations consisted almost entirely of grasses and forbs during late winter and early spring. An abundance of manzanita flowers in the chaparral was highly preferred, but leaves and twigs were avoided. Oak leaves and acorns were important summer foods. Following fire, the rapid regrowth of brush from seedlings and crown sprouts provides a high nutrient food source in the chaparral; however, it is still inferior to the oak-woodland type.

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Table 23. Principal Food Items Eaten by Deer in Oak-Woodland and Chaparral Types on Cow Mountain, Calif. (Longhurst 1969)

SPRING Feb.-Apr.		Oak-woodland	Burned chaparral	Unburned chaparral
Number of rumen samples (2 yrs)		10	12	5
Food Items			Volume in percent	
Grasses		55	15	1
Manzanita	flowers	1	16	65
Chamise	leaves		37	4
Poison oak	leaves			20
Oaks	leaves	6	16	8
Wedgeleaf ceanothus	leaves		11	2
Filaree	leaves	8		
Vetches	leaves	9		
Buckeye	leaves	5		
Lichens		8		
Forbs		8	4	
SUMMER Aug.-Sept.				
Number of rumen (3 yrs)		16	11	
Oaks	acorns	53	9	
Oaks	leaves	14	69	
Grasses		13	1	
Poison oak	leaves		9	
Chamise	leaves		6	
Lichens		6		
Bur clover	fruits	5		
Other forbs		5	2	
Wedgeleaf ceanothus			2	
Coffeeberry		3		

Table 24 is a summary of rumen contents data from a California-Oregon Interstate Committee report (Interstate Committee 1951). These samples were collected from the winter range in California and the summer range in Oregon during the period 1945-1951. The report notes the substantial use of grass and forbs, particularly the dry plants taken in fall and winter. Forage conditions on the winter range were described as considerably depleted. It was also noted that deer changed from bitterbrush to sagebrush in midwinter. Table 7 gives an indication that this may be related to protein content.

Table 24. Summary of Rumen Contents From Deer on the California-Oregon Interstate Herd Range. Percentage (Interstate Comm. 1951) of Volume.

Months Collected No. of Deer	Jan 16	Mar 15	May 5	Jul 5	Sep 6	Nov 50
Grass, green and dry	23.7	59.5	3.0	38.2	15.8	37.3
Forbs and fungi	15.7	0.0	93.0	27.4	6.0	4.0
Purshia tridentata	8.5	1.2	0.0	Tr	0.8	18.9
Artemisia species	34.6	13.8	Tr	0.0	0.0	1.4
Juniperus occidentalis	17.5	23.4	Tr	0.0	0.0	14.3
Ceanothus velutinus	0.0	0.0	0.0	27.4	25.0	0.0
Cercocarpus ledifolius	0.0	0.0	0.3	0.0	15.8	2.1
Ceanothus prostratus	0.0	1.4	0.4	0.0	4.1	19.8
Other browse & lichens	0.0	0.7	3.3	7.0	32.5	2.2

The Interstate Deer Herd Committee (1954) reported on contents of 99 stomachs from winter-killed deer on the Devils Garden range in northeastern California. Table 25 indicates the diet of deer which did not survive on a poor-condition range during a severe winter. An estimated one-third of the herd was lost.

Table 25. Food Items Eaten by 99 Winter-Killed Deer in Northeastern California. 1951-52. (Interstate Deer Herd Comm. 1954)

	Casuse Mt. 55 deer		Sagehorn 44 deer	
Food Items	Volume %	Freq. %	Volume %	Freq. %
Juniper	54.0	100	54.4	100
Sagebrush	15.0	91	8.0	64
Rabbitbrush	1.3	24	1.4	25
Bitterbrush	Tr	4	-	-
Rock lichen	0.6	15	Tr	7
Tumbling mustard	0.3	24	1.8	25
Moss	Tr	33	Tr	9
Filaree	Tr	2	Tr	7
Forb sp. (dry)	Tr	7	-	-
Grass (dry)	26.8	91	30.7	93
Grass (green)	2.0	71	3.7	66
Cheatgrass	Tr	67	Tr	73

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The following tables (26 through 32) are condensed from tables appearing in the cited theses reporting on studies at the University of Nevada, with cooperation and financial assistance from the Nevada Fish & Game Commission and BLM. Each student covered a two-year period in a continuing project. The primary objectives were to evaluate potential forage production and condition of selected habitats, to conduct forage utilization studies, investigate effects of selected range improvement projects, and undertake deer food habits and nutrition studies. Study sites were on summer and winter mule deer ranges in Nevada. Descriptions of these plant communities will be found in the theses and in Berg (1966).

Table 26. Food Items Identified From Rumen Samples Collected on Fox Mountain, Washoe County, Nevada, in 1964 and 1965. Weight and Frequency Values are Means of Five Deer for Each Date, Expressed in Percent. (Doughty 1966)

	1964							
Food	May		July		Sept		Summer	
Items	Wt.	Freq.	Wt.	Freq.	Wt.	Freq.	Wt.	Freq.
Grass	49	100	2	60			17	53
Forbs	5	80	12	100	7	100	8	93
Putr	2	40	51	100	39	100	30	80
Cele	33	100	9	60	28	100	23	87
Prem			3	20	9	20	4	13
Ceve	2	20	15	80			6	40
Amal			5	40	9	80	5	40
Artem	9	60					3	27
			1965					
Grass	9	100					3	67
Forbs	8	80	8	100			5	67
Artem	4	100			10	100	5	73
Cele	46	80			19	100	25	87
Ceve	2	40	12	80	27	80	14	67
Putr	24	100	56	100	5	40	28	80
Sylo	2	60			10	80	4	47
Prvi			10	60	7	80	6	53
Prem					22	80	7	33

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Table 27. Food Items Identified From Rumen Samples Collected on Bates Mountain, Lander County, Nevada, in 1964 and 1965. Weight and Frequency Values are Means of Five Deer for Each Date, Expressed in Percent. (Doughty 1966)

	1964							
Food	May		July		Sept		Summer	
Items	Wt.	Freq.	Wt.	Freq.	Wt.	Freq.	Wt.	Freq.
Grass	17	100	2	80			7	73
Forbs	57	100	69*	100	44	100	57	100
Potr-l			14	60	43	100	19	53
Artem	6	100	7	100			4	87
Amal	17	80	5	100			8	67
Prvi			2	40	10	20	4	33
			1965					
Grass	6	80	2	80			3	53
Eriog	2	40	33	100	6	40	13	60
Phlox			11	100			4	33
Crac	2	40					1	13
Basa	1	40			2	40	1	27
Penst			5	80			2	27
Forbs-other	13	80	15	100	21	80	17	87
Artem	10	80	26	100	4	40	13	73
Amal	25	80	8	60			11	47
Sylo	36	80			3	40	13	40
Prvi	8	60			24	80	11	60
Potr-l					13	40	4	13
Cele					3	40	1	13
Ceve					7	40	2	13
Rosa					20	20	7	7

* Includes 30 percent Eriog

MULE DEER

Table 28. Food Items Identified From Rumen Samples Collected on Deer Winter Ranges in Nevada During 1964-65. Weight and Frequency Values are Means of Five Deer for Each Date, Expressed in Percent. (Doughty 1966)

	Morey Bench, Nye County							
Food	Dec		Jan		Mar		Winter	
Items	Wt.	Freq.	Wt.	Freq.	Wt.	Freq.	Wt.	Freq.
Grass					5	60	2	40
Artem	12	80	12	100	12	100	12	93
Pugl	64	80	47	100	22	100	44	93
Juos	16	40	4	80	29	100	16	73
Cele	3	20					1	7
Amal	1	20	10	20			4	13
Pimo	2	60	23	100	30	100	18	87
	Pequop Mts., Elko County							
Grass			1	100	13	100	5	73
Forbs	6	40	5	60	1	40	4	33
Artem	28	100	21	100	24	100	24	100
Putr	17	60	6	40	5	60	10	53
Come			11	20			4	7
Cele	41	60	18	60	7	20	22	47
Pimo	5	20	5	60	14	60	8	47
Juos	1	20	32	100	35	80	23	67

MULE DEER

Table 29. Food Items Identified From Rumen Samples Collected on Fox Mountain, Nevada, in 1966 and 1967. Weight and Frequency in Percent. (Deibert 1968)

	1966							
	May		July		Sept		Dec	
Samples	5		6		5		3	
Species	Wt.	Freq.	Wt.	Freq.	Wt.	Freq.	Wt.	Freq.
Amal	14	80	2	33	2	60		
Artem	12	100	4	100	4	60	83	100
Ceve	4	60	17	83	11	80		
Cele	19	80	39	100	56	100		
Prem	9	40	2	33				
Prvi	2	60	7	33	2	20		
Putr	29	100	21	100	16	100	1	33
Sylo	6	80	4	50	7	100		
Forbs	3		2				7	100
Grass	1	40			1	60	5	100
			1967*					
Samples	5		5		4		3	
Amal	4	60	19	100	1	50	2	33
Artem	15	100	3	100	8	100	67	100
Ceve	20	60	6	80	9	75		
Cele	8	20	20	100	34	100		
Juos	1	20					5	33
Prem			15	40	11	50		
Prvi	6	60	16	100	11	100		
Putr	16	40	17	100	18	100	1	67
Salix							14	100
Sylo	3	60	1	60	1	25		
Forbs	19		2		2		9	
Grass	7	80	1	40	4	100	1	67

* March diet of 2 deer: Artem 56, Salix 5, Grass 34% wt.

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Table 30. Food Items Identified From Rumen Samples Collected at White Rock, Lincoln County, Nevada, in 1966 and 1967. Weight and Frequency in Percent. (Deibert 1968)

	1966							
	Mar		May		July		Sept		Dec	
Samples	0		0		5		6		5	
Species	Wt.	Freq.	Wt.	Freq.	Wt.	Freq.	Wt.	Freq.	Wt.	Freq.
Amal					14	80	35	100		
Artem					13	100	5	83	33	100
Cele					2	20	7	67		
Come									21	60
Juos					3	40	2	50	20	100
Pimo					10	20			15	80
Prvi					2	60	5	50		
Pugl					51	100	25	83	12	60
Forbs					3		1			
Grass					1	80	2	50	1	80
	1967							
Samples	6		6		6		5		6	
Shrubs										
Amal					19	100	18	80		
Artem							8	80	29	100
Cebe	21	100	37	100	5	100	12	40		
Cele					5	50				
Come									12	100
Juos	23	65	17	83	3	33			20	100
Pimo	30	100	11	67	2	33				
Prvi					2	33	4	60		
Pugl	2	67	5	33	40	67	42	100	40	87
Rhtr							4	20		
Rosa							6	20		
Forbs										
Debr	10	50								
Eriog	2	83	2	83	1	50	1	40		
Phlox			17	83						
Grass	11	100	9	100	1	83				

MULE DEER

Table 31. Food Items Identified From Rumen Samples Collected at Ruby Butte, Elko County, Nevada, in 1968-70. Dry Weight and Frequency in Percent. (Delmas 1971)

	1968-69									
	June		July		Sept		Dec		Mar	
Samples	3		4		5		6		11	
Species	Wt.	Freq.	Wt.	Freq.	Wt.	Freq.	Wt.	Freq.	Wt.	Freq.
Shrubs										
Amal	3	67	36	100						
Artr-1							55	83	12	73
Artem							8	17	8	27
Cele							15	50	11	36
Ceve	11	67								
Juos							5	50	55	100
Pimo									10	55
Potr-2					6	20				
Prvi	48	100	5	100	21	40				
Putr	4	33	23	100	52	80	7	83		
Riau			5	50						
Forbs										
Basa					5	20				
Geran			8	25						
Urtic					6	20				
Wyam	11	67								

	1969-70									
	May		July		Sept		Dec		Mar	
Samples	6		6		2		10		11	
Species	Wt.	Freq.	Wt.	Freq.	Wt.	Freq.	Wt.	Freq.	Wt.	Freq.
Shrubs										
Amal			16	100	29	100				
Artem									18	27
Artr-1	25	100					46	100	28	73
Cele	4	50					28	80	28	82
Ceve	5	17	15	33						
Juos							4	40	6	64
Potr-1					7	100				
Prvi			30	100	5	100				
Putr			9	83	33	100	10	70		
Rowo					14	50				
Forbs										
Crac	17	83								
Lomat	5	50								
Lupin			5	17						
Penst	8	67								
Grasses	9	100							17	100

Table 32. Food Items Identified From Rumen Samples Collected at Ruby Butte, Elko County, Nevada, in 1970-72. Dry Weight and Frequency in Percent. (Pudney 1972)

	Winter		Spring		Summer		Year-round	
Samples	17		44		22		83	
Species	Wt.	Freq.	Wt.	Freq.	Wt.	Freq.	Wt.	Freq.
Browse								
Amal			3	24	28	82	11	36
Attr-1	35	89	36	100			23	61
Bere	5	38					2	15
Cele	24	57	7	48			11	37
Ceve			3	4	4	9	2	5
Come	4	14					1	6
Juos	20	72	6	44			9	38
Prvi			1	13	20	86	7	35
Putr	5	53	7	78	23	82	12	70
Rowo					3	46	1	19
Forbs								
Coli					6	59	2	22
Penst	3	11					1	4
Grasses	1	56	25	100	2	73	8	74
Totals								
Browse	94.9		65.1		80.9		81.7	
Forbs	3.8		8.2		15.6		9.3	
Grass	1.2		25.2		2.0		8.0	

d. Salt. Opinions differ on the need for salt by wild deer. Salt consumption by deer is affected by the nature of the forage, air temperature, and exercise. Apparently, a diet high in leguminous forage will tend to increase salt consumption. If deer do require salt, a deficiency of the mineral is most apt to occur on most ranges in spring when the animals turn to fresh green herbaceous foods, and for 5 or 6 weeks after fawning. A high salt intake can be dangerous when animals are on a protein-deficient diet and are semi-starved, a not uncommon condition on over-browsed winter ranges (Dasmann 1971). Both Nichol (1938) and Hill (1956) have reported an average use by deer of available salt of 0.1 to 0.2 pounds per deer per month in summer and 0.05 to 0.15 pounds in winter. Hill notes the use of natural licks during the summer. Leopold et al (1951) reported that deer used salt put on summer range for cattle, but where there was none the deer seemed to get along as well.

5. Water. Deer must have water. An adequate water supply is an essential ingredient of all deer ranges. Need for drinking water is much less when succulent vegetation is available than when plants are dry or dormant. Water undoubtedly can be a limiting factor in arid areas (Dasmann 1971). Temperature, evaporation, water content of feed, and exercise all influence the amount of water utilized. On several southern Arizona ranges, a high fawn mortality definitely can be correlated with a low, stagnant water supply.

Captive deer in southern Arizona required an average of one to one and one-half quarts of water per hundredweight in winter and from two to three quarts in summer (Nichol 1938). Elder (1954), in Arizona, observed that deer watered at least twice daily and consumed an average of 6.3 quarts per drinking period. Swank (1958), in Arizona, found that most watering occurred soon after sunrise and especially at sunset. In summer, deer watered up to one and one-half hours before sunset, and usually watered more than once each day. Fawns one month of age were observed drinking water.

Swank reported that deer congregated around water during the dry period of the year when plants are dormant. Water dispersal at two mile intervals was considered ideal as, in chaparral, one mile is about the distance deer will move to water in the driest months. Hansen and McCulloch (1955) estimated deer would not go over one and one-half miles under the same conditions and observed that when watering sites dried up, deer moved and concentrated in other watered areas. At Fort Stanton, in south-central New Mexico, range use by deer decreased as the distance from water increased (Wood et al 1970). Range within one-half mile of water received twice as much use as range one-half to one mile distant and four times as much use as range over a mile from water. Wood concluded that deer are very much dependent upon free water and about one and one-half miles was about the maximum distance they would move from it. In Utah, Julander (1966) reported that water may be an important factor in the distribution of deer on dry, fall ranges, but on some summer ranges intensity of use may increase with distance from water because of better forage.

Mackie (1970), in eastern Montana, reported that most deer were observed within three-quarters of a mile of a water source (Table 33). This distance generally reflected the distribution of water sources in relation to areas used by deer during different seasons and years. The observations were related more to intensities of use of vegetation types rather than to distance. The distribution of water was not significant in determining deer distribution within seasonal ranges.

Table 33. Percentages of Deer Observed Within Various Distances of Water Over a 4-year Period in Eastern Montana. (Mackie 1970)

Season	Observations	Miles				
		1/4	1/2	3/4	1	1-1/2
Summer	2256	23	50	72	84	96
Fall	1647	27	56	75	87	97
Winter	2932	19	41	66	85	96
Spring	4746	15	39	70	87	98
Yearlong	11581	19	44	70	86	97

6. Space. The size of a range may limit the number of deer it can support. Spatial limits do exist -- e.g., on a chaparral range in northwest California the saturation level for breeding black-tail doe appears to be about 36 per square mile. Spatial requirements may vary with differing food-water-cover combinations, but there is little doubt that there is a limit beyond which crowding becomes detrimental. This results from intensive competition for food, water, and cover, the increased possibility of spreading disease and parasites, and from tensions caused by social stress (Dasmann 1971).

Some reports of high deer densities include the following. In California, Longhurst et al (1968) stated that deer numbers often exceeded 100 per square mile on Cow Mountain in the north Coast Range. Biswell et al (1952), reporting on chamise brushland in the north Coast region of California, found 10 to 30 deer per square mile in mature brush and 40 to 110 per square mile in areas opened by fire.

In Arizona, Swank (1958), estimated deer-carrying capacity of chaparral ranges to average 10 (range 5 to 30) per square mile. The actual density was about 70 deer per square mile of occupied habitat. The usual stocking rate for cattle was given as 7 head per square mile. North of the chaparral zone the deer density on entire year-long range was up to 26 per square mile, but winter concentrations reached 60 deer per square mile.

Richens (1967), working in northeastern Utah, reported the average deer density on winter range in normal years was 46 per square mile, but on seven major concentration areas it varied from 81 to 135 deer per square mile.

F. Management Factors.

1. Compatibility With Other Wildlife. According to Taylor et al (1956), insects, rabbits, rodents, birds, bighorn sheep, and elk (in addition to livestock) are some of the more important competitors of deer. The more limited browsing height reached by deer, as compared, for example, with elk, is a disadvantage on heavily stocked dual-use ranges.

Mule deer - elk relations were studied by Mackie (1970) in the Missouri River breaks of Montana. Elk were highly mobile and were much more responsive than deer to forage availability. Elk used most habitat types, sites, and classes of forage. Deer used a limited number of types and ate little grass. Both species intensively utilized south slopes of the sagebrush-wheatgrass type in spring. Food preferences were most alike between April and September. Forbs and Sandberg bluegrass were principal items in early spring, and forbs (especially yellow sweetclover) were used by both animals during the summer. Key forage species for deer in the fall and winter were shrubs; elk utilized grass. Mackie concluded that direct competition must have occurred during the April to September period and especially in early spring of most years (Table 34).

Table 34. Percentage of Feeding Observations Recorded for Principal Food Items and Class Totals by Season for Deer and Elk in Eastern Montana. (From Tables 25 and 30 Mackie 1970)

Food Items	Deer				Elk			
	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring
Agsm				2	8	30	62	55
Pose		6	2	10		15	6	15
Meof	45	14	3	2	53	12		1
Artem		17	40	25		5	11	4
Chna		9	11	1				
Chvi		15	8	2		2		
Rhtr	25	15	5	4	1			
Grass		5	2	13	11	62	78	82
Forbs	56	23	10	35	75	23	5	13
Shrubs	43	72	87	52	14	15	17	5

Allen (1968) found that despite similarity of food habits there was little competition, particularly during winter and spring, between white-tailed deer and mule deer on the Missouri bottoms.

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Reynolds (1962, 1966), in Arizona, found that deer made equal use of openings, borders, and forest in a selectively logged Ponderosa pine forest, whereas elk, like cattle, preferred openings. In the spruce-fir forest, deer preferred the forest and forest border to natural openings; elk showed little preference. Openings larger than 20 acres were little used by either species.

Cowan (1947), in Jasper Park, Alberta, observed food preferences of mule deer, elk, and bighorn sheep on an overutilized winter range under bare ground conditions in December (Table 35).

Table 35. Forage Utilization by Deer, Elk, and Sheep on an Overutilized Winter Range in Alberta. (Cowan 1947)

Food Items	Deer	Elk	Sheep
	Percent		
Grass	15	97	83
Forbs	6	-	10
Shrubs	79	3	7

Cowan reported that the conflict for palatable browse was already past. The elk had cleaned out willow and aspen above the deer's reach. Elk were in serious competition with bighorn sheep and deer, but there was little competition between the latter two. Cowan (1950) wrote that elk were introduced to those mountain ranges long ago, competed for food and became dominant. The deer and moose populations declined.

Morgan (1969) studied bighorn sheep in the Salmon River country of Idaho and reported some competition between sheep and mule deer, especially for browse in winter (Table 36).

Table 36. Summary of Forage Utilization Observations, During Winter of 1966-67, of Mule Deer and Bighorn Sheep. Total of 31,298 Observations. In Percent. (Morgan 1969)

Food Items	Dec	Jan	Feb	Mar	Apr	Total
Grass						
Sheep	62	66	67	75	83	69
Deer	16	12	14	34	61	24
Forbs						
Sheep	7	5	2	1	3	4
Deer	17	11	15	7	16	15
Shrubs						
Sheep	31	29	31	24	14	27
Deer	67	77	71	59	23	61

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Halloran and Kennedy (1949) stated that bighorn sheep and mule deer competed for food on San Andres Mountain in southern New Mexico. Both animals ate green grass when available. Fifteen out of 33 listed species were utilized by both sheep and deer.

On the east slope of the Sierras in California, where mule deer winter range overlaps with Tule elk summer habitat, the animals compete for bitterbrush. Elk eat a wide range of foods, but in winter deer are much more dependent on bitterbrush. Transects showed 82 percent use of bitterbrush in one good year, of which elk took 39 and deer 43 percent. The next was a poor growing year; elk took 6 and deer 34 percent of the bitterbrush production (McCullough 1969).

2. Compatibility With Livestock.

a. General. A survey by Aldous (1949) disclosed that most western State game departments recognized livestock as a contributing factor in most problem areas due to overutilizing the range and competing with deer for the forage. These problems usually related to deer winter range. The key areas of big game winter range and spring range for livestock are often one and the same (Stoddart and Rasmussen 1945).

Dasmann (1962), in California, wrote that free grazing on public lands caused a tremendous build-up in livestock numbers late in the last century. In California as early as 1876 the problem of overgrazing and range depletion was recognized. With these depleted range conditions, several extremely severe winters reduced the deer population to a low ebb around the turn of the century.

Cattle, sheep, and deer all eat grass, forbs, and shrubs. Deer on many ranges will eat grass and forbs whenever available in a succulent growth stage. Livestock, primarily grass and forb eaters, take to browse whenever the grass supply decreases in nutritive value. Livestock have been and are important competitors with deer, especially on heavily stocked ranges. Cows and deer usually get along well together under moderate use, and, in fact, provide a more balanced use of the vegetation. Competition for food is most intense with sheep, and least with horses (Doman and Rasmussen 1944, Dasmann 1971, Julander 1966, Smith 1949).

b. Cattle.

(1) General. Skovlin et al (1968) reported on a 10-year study conducted in typical ponderosa pine-bunchgrass summer range in northeastern Oregon, to determine relationships between deer, elk, and cattle. They found that big game made the greatest average use of ranges where cattle did not graze, however deer use of grasslands on the game-only ranges declined somewhat during this period. As intensity of cattle grazing increased on dual-use ranges, deer appeared to make greater use of grassland openings - presumably, in part, due to fall regrowth of bunchgrass. Deer had a tendency to use both grassland and forest more under deferred-rotation than under season-long grazing by cattle. This probably was due to the presence of more ungrazed plants. Heavy cattle use discouraged big game use. Moderate cattle grazing had little effect on deer use. There was little evidence of direct competition between big game for forage volume; cattle did compete indirectly since they definitely influenced patterns of game use. Competitive use of cattle forage by deer was small, but the use of forage by cattle important to big game was great. Competition was related to the availability of ungrazed plants. On the same Starkey Experimental Forest on ponderosa pine-Douglas fir range, Edgerton and Smith (1971) found competition was most likely to occur in the open forest in summer and fall.

On properly used range in Utah, Stoddart and Rasmussen (1945) estimated it would take up to 32 deer to consume the forage that one cow would eat. Four cows would eat forage that would provide for five deer.

Swank (1958), in Arizona, found competition to be high in fall and winter when cattle use much browse. Deer compete with cattle for a short period early in the growing season for green grass. On Kaibab North, yearlong, cattle diet was about 17 percent browse, deer diet was approximately 3 percent grass. In chaparral, seven cattle on one square mile would consume about the same amount of deer forage as 30 deer. Livestock overuse of grasses has favored growth of browse plants.

(2) Vegetation Types. In the Missouri River breaks of eastern Montana, Mackie (1970) observed that of eight or more habitat types, two-thirds of the yearlong use by both deer and cattle was on the Artemisia-Agropyron type, principally big sagebrush and western wheatgrass (Table 37).

Table 37. Percentages of Feeding Observations for Deer and Cattle on the Principal Habitat Types, by Seasons, for a 4-year Period. Eastern Montana. (Mackie 1970)

Type	% of Total Range	Spring		Summer		Fall		Winter		Year-long	
		Deer	Cows	Deer	Cows	Deer	Cows	Deer	Cows	Deer	Cows
Artr-Agsm	31	76	70	31	59	37	64	67	66	61	64
Pipo-Jusc	45	14	9	41	16	29	14	24	7	23	13

The greatest overlap in use was in April and early May on the Artemisia-Agropyron type for grass and forbs. There was only minor overlapping for the balance of the year (Table 38).

Table 38. Percentages of Feeding Observations in the Artemisia-Agropyron Type by Forage Class and Season. Eastern Montana. (Mackie 1970)

Food Items	Spring		Summer		Fall		Winter	
	Deer	Cows	Deer	Cows	Deer	Cows	Deer	Cows
Grass	16	79	Tr	66	18	78	2	83
Forbs	49	20	94	31	45	16	10	3
Shrubs	35	Tr	6	3	37	6	88	14

On a northeastern Utah summer range, cattle constantly preferred the grass-forb type which was the least preferred by deer. Deer changed preferences with the season, utilizing mixed shrub, Gambel oak, aspen, and open conifer types avoided by cattle (Julander and Jeffrey 1964).

(3) Slopes. Mackie (1970), in eastern Montana, found that on preferred vegetation types, cattle made only light or occasional use of steep slopes. Steepness of slope exerted an important influence on the distribution of cattle (Table 39).

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Table 39. Percentage of Cattle and Deer Observed as Related to Slope Occupied, all Seasons, Over a Four-year Period, in the Missouri River Breaks, Montana. (Mackie 1970)

	No. of Observations	Percent slope		
		0-10	11-25	25+
Deer	11,581	54	22	24
Cattle	25,107	82	13	4

On summer range in northeast Utah, deer preferred upper and middle slopes and ridgetops with heaviest use on slopes of 30 percent or more. Cattle used the least-steep slopes (Julander and Jeffrey 1964).

Reynolds (1964), in southern New Mexico, primarily in the pinyon-juniper type, found deer using slopes up to 40 percent and cattle on gentle slopes. He recommended preserving overstory and shrub cover on north-east exposures for deer habitat.

(4) Forest Openings. Among timber management practices known to influence use of forest range by deer and cattle in Arizona and New Mexico are: selective logging, thinning, patch clearcutting, and slash disposal. Deer habitat is benefited by:

. Maintenance of natural forest openings

. Restriction of clearcuts to less than 20 acres in spruce-fir, and less than 45 acres in ponderosa pine forests.

. Leaving some lightly thinned islands of timber reproduction of 10 to 30 acres in size.

. Leaving slash undisturbed. (Reynolds 1969)

Deer prefer forest habitat and will utilize borders and small openings whereas cattle prefer openings regardless of size (Julander and Jeffrey 1964; Reynolds 1962B, 1966A, 1966B; Skovlin et al 1968). Cattle preferred natural openings to clear-cut openings; deer favored created openings. Deer preferred areas where slash was undisturbed whereas cattle made better use of selectively logged ponderosa pine sites in Arizona where slash was removed. In the spruce-fir forest, understory vegetation tripled in production and use doubled when about one-half the timber was removed. It reached peak production about 6 years after logging and the effect continued for up to 15 years. Patch clearcutting of up to 20 acres benefited deer more than cattle. About 15 to 20 forage species were common in clearcuts, while only two species were common in uncut forest. Tame deer spent 70 percent of their grazing time in clearings (Reynolds 1966A, 1966B).

Cattle may open up certain dense stands of brush that otherwise would be inaccessible to deer, for example in the California chaparral (Leopold et al 1951).

(5) Forage Species. In late summer, cattle eat progressively more browse. In the California Sierras, willow and aspen are often highlined by heavy cattle use around meadows. Mountain whitethorn is a preferred summer food for deer, and in late summer for cattle. Both animals make much use of bitter cherry, black oak, and deer brush. Shrubs little used by deer are likewise unused by cattle (Leopold et al 1951). McCulloch (1969), in Arizona, also found that cattle seemed to prefer the same shrubs that deer do, and on browse ranges there was much competition. In Nevada, Lesperance and Tueller (1969) reported that bitterbrush was the most important browse species selected in common by both cattle and deer. Season long, however, cattle diet was eighty percent grass and forbs, and deer diet was eighty percent shrubs.

Skovlin et al (1968), in Oregon, found deer using plants not important to cattle or not accessible to them. There was little direct competition for particular species, but cattle did compete indirectly by influencing deer patterns of range use.

(6) Water. In eastern Montana, Mackie (1970) observed that cattle were usually within a half-mile of water (Table 40). In dry years when the number of water sources was minimal, a larger percentage of deer was more than one-half mile, and cattle less than one-half mile, from water.

Table 40. Observations of Deer and Cattle as Related to Distances to a Water Source. Montana. (Mackie 1970)

	No. of Observations	Miles				
		1/4	1/2	3/4	1	1 1/2
Deer	2256	23	50	72	84	96
Cattle	10700	38	62	82	94	99

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c. Sheep. Sheep feeding habits more closely resemble those of deer than do cattle. When sheep range is overgrazed, the competition with deer may be severe because the sheep will take what deer normally eat (Stoddart and Rasmussen 1945). Competition is more direct than with cattle, but sheep and deer can occupy the same range harmoniously where sheep numbers are held to a moderate level and they are removed from the range during winter. In Utah, in spring and summer, sheep and deer ate large quantities of the same plant species. Deer wintered on the sheep fall range. Sagebrush made up 64 percent of the deer diet versus 3 percent for sheep (Smith and Julander 1953). Smith (1953), test feeding sheep and deer, found that both animals tended to shift from forbs to browse as the season progressed (Table 41).

Table 41. Comparison of Deer and Sheep Forage Preferences Under Test Feeding in Utah. (Smith 1953)

	Mid-July		Early Aug.		Early Sept.		Late Sept.	
	Sheep	Deer	Sheep	Deer	Sheep	Deer	Sheep	Deer
Browse	2	44	15	42	49	73	68	87
Forbs	92	55	85	58	49	27	30	13
Grass	6	1	0	0	2	0	2	0

Jensen et al (1971) in Utah, reported a sheep diet consisting of 46 to 74 percent forbs. Grasses were important in late May, and in October when they amounted to 25 percent of the diet. Utilization of bitterbrush, the shrub most involved in competition, was moderate prior to early July. Thereafter, utilization exceeded 33 percent of current production. Seasonally, it was the most preferred plant species. Use after June greatly reduced herbage available to big game in winter.

3. Damage to Cultivated Crops. Damage by deer to cultivated farm or horticultural crops probably has been occurring wherever and whenever the two ranges coincide, over a long period. Dixon (1934) wrote of damage to deciduous orchards, vineyards, truck, and other field crops, especially in the foothills of California. Grapes and many kinds of fruit and nut trees were mentioned. Truck crops, including: watermelons, casabas, cantaloupes, squash, corn, cabbage, lettuce, carrots, potatoes, and beans were all acceptable fare. Forage crops attractive to deer include: alfalfa, clover, vetch, oats, barley, and wheat. Alfalfa fields and stacked hay are often preferred over poor, dry rangeland or snow-covered winter ranges. Harder (1970), studying orchard damage in western Colorado, declared that browsing did not appear to affect mortality or vigor of trees, but did interfere with development of young trees - especially through removal of terminal buds. Antler rubbing was detrimental to young trees. Most browsing was in old orchards, especially in the fall and winter.

4. Range Development. Results of studies on the impact of sagebrush spraying, pinyon-juniper chaining, and grass seeding on deer habitat are not unanimous.

Tausch (1973) showed that deer use was highest on those areas originally containing the greatest diversity of native non-tree vegetation. The level of use was dependent upon the nearness of untreated escape cover and on the close proximity of the treated area to an existing high deer use region. Most treated areas did not become preferred habitat for deer. On all pinyon-juniper chainings, Sitanion hystrix was consistently found to be positively correlated to deer use. Little deer use was found on crested wheatgrass-seeded chainings. If the objective is to improve deer habitat, it was recommended that more intensive treatment be given smaller areas, stressing complete tree removal and seeding to preferred forage species.

Cole (1968) stated that seeding crested wheatgrass for mule deer use was without justification. Field reconnaissance of 25 crested wheatgrass seedings revealed that mule deer winter range in Nevada is not extended by this practice. Little use was made beyond the field edges. It was concluded that replacement of browse winter range with wheatgrass seedings resulted in loss of forage and cover for deer. Also, there was no extension of range use to seedings outside of existing deer range. On pinyon-juniper chaining projects, bitterbrush and cliffrose were relatively unaffected. Forbs and grasses increased significantly. The release of understory species resulted in increased use of treated areas, especially adjacent to the edges. Limiting treatment to small areas was recommended.

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Leckenby (1968), in Oregon, reported that crested wheatgrass seedings within deer winter range initiated growth before deer left in the spring. They removed 40 to 60 percent of the new growth where cattle had reduced old straw accumulation, but used only 10 to 20 percent where cattle were excluded. Seedings were valuable additions to natural range communities but could not replace them.

Urness (1966) found that seedings of crested wheatgrass in central Oregon were very attractive to deer in winter when green grass was available. Seedings tended to create a diversified forage resource that enhanced use of surrounding untreated sagebrush. It was concluded that deterioration of key browse forage, such as bitterbrush, is a greater threat to deer range carrying capacity than existing and well-planned future sagebrush control programs.

In an inventory of range manipulation projects in Colorado (Kufeld 1968), 83 percent of the 23 sagebrush spray projects appraised on fall-winter-spring deer range were considered to be detrimental to deer, and none were believed to be beneficial. Thirty-eight percent of the 16 pinyon-juniper chainings appraised on fall-winter-spring deer ranges were considered to be beneficial to deer, 56 percent were considered detrimental, and 6 percent were thought to have no effect. A significant decrease in deer use was recorded on some sagebrush winter ranges after spraying. The impact of chaining depended upon the reaction of understory browse plants, and upon the size of the treated area.

Reynolds (1964) recommended leaving pinyon-juniper on slopes of more than 15 percent if improving range for cattle and deer. Annual growth of shrubs was more than twice as great where the tree overstory was removed. Where shrub density prevents access by deer, top removal was recommended to induce sprouting of species such as birchleaf mountain mahogany, Wright silktassel, and wavyleaf oak.

From the standpoint of food contribution, trees, such as juniper and pinyon, could be sacrificed. With an adequate shrub stand of 25 to 50 plants per acre (New Mexico), the trees are unnecessary even for cover. Removal of the trees should enhance the growth of shrubs and forbs to the overall benefit of the deer habitat (Boeker et al 1972). However, any program that removes or drastically reduces forbs and browse on areas occupied by deer will, in all probability, be detrimental to their welfare. The removal of sagebrush on winter ranges would apparently be most detrimental to mule deer (Quimby 1966).

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Plant Reference List

Scientific Name	Common Name	Symbol*
	Grasses and Grasslike	
Agropyron cristatum	Crested wheatgrass	
Agropyron smithii	Western wheatgrass	Agsm
Agropyron spicatum	Bluebunch wheatgrass	
Bromus tectorum	Cheatgrass	
Carex geyeri	Elk sedge	
Dactylis glomerata	Orchard grass	
Danthonia unispicata	One-spike oatgrass	
Festuca elatior	Meadow fescue	
Festuca idahoensis	Idaho fescue	
Holcus lanatus	Velvet grass	
Koeleria cristata	Junegrass	
Phalaris tuberosa	Harding grass	
Poa secunda	Sandberg bluegrass	Pose
Sitanion hystrix	Squirreltail	
Stipa species	Needlegrass	
	Forbs	
Adenocaulon bicolor	American trail plant	
Agoseris species	Agoseris	
Allium textile	Textile onion	
Apocynum species	Dogbane	
Arnica cordifolia	Heartleaf arnica	
Aster engelmanni	Engelmann aster	
Aster modestus	Few-flowered aster	
Astragalus species	Astragalus	
Balsamorrhiza sagittata	Balsamroot	Basa
Camassia quamash	Common camas	
Cirsium species	Thistle	
Collomia linearis	Thinleaf collomia	Coli
Commelina dianthifolia	Birdbill dayflower	
Crepis acuminata	Tapertip hawksbeard	Crac
Cucurbita foetidissima	Buffalogourd	
Dalea species	Dalea	
Dasylirion wheeleri	Sotol	
Delphinium nelsoni	Menzies larkspur	
Descurainia brachycarpa	Tansymustard	Debr
Descurainia obtusa	Obtuse tansymustard	
Descurainia pinnata	Pinnate tansymustard	
Desmanthus cooleyi	James bundleflower	

* Symbol designated for species as listed in tables.

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Scientific Name	Common Name	Symbol
	Forbs (continued)	
Erigeron species	Daisy	
Eriogonum species	Wild buckwheat	Eriog
Erodium cicutarium	Filaree; storksbill	
Geranium richardsoni	Richardson geranium	
Geranium species	Geranium	Geran
Heracleum lanatum	Common cowparsnip	
Lactuca serriola	Chinese lettuce	
Lomatium foeniculaceum	Biscuitroot	
Lomatium leptocarpum	Bicolor biscuitroot	
Lomatium species	Biscuitroot	Lomat
Lotus americanus	Spanish clover	
Lupinus argentea	Silvery lupine	
Lupinus species	Lupine	Lupin
Medicago hispida	Bur clover	
Medicago lupulina	Black medic	
Medicago sativa	Alfalfa	
Melilotus officinalis	Yellow sweetclover	Meof
Penstemon linarioides	Toadflax penstemon	
Penstemon species	Penstemon	Penst
Phlox species	Phlox	Phlox
Polemonium albiflorum	Skunk flower	
Polygonum aviculare	Knotweed	
Ranunculus species	Buttercup	
Rumex crispus	Curly dock	
Salsola kali	Russian Thistle	
Sidalcea oregona	Oregon checkermallow	
Sisymbrium altissimum	Tumble mustard	
Sphaeralcea incana	Big mallow	
Taraxacum officinalis	Dandelion	
Thalictrum fendleri	Meadow rue	
Tragopogon dubius	Salsify	
Trifolium species	Clover	
Urtica species	Nettle	Urtic
Vicia species	Vetch	
Wyethia amplexicaulis	Mule's ear	Wyam
	Shrubs and Trees	
Abies magnifica	Red fir	
Acacia greggii	Catclaw	
Adenostoma fasciculatum	Chamise	
Aesculus californicus	California buckeye	
Agave parryi	Agave	
Alnus species	Alder	
Amelanchier alnifolia	Serviceberry	Amal

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Scientific Name	Common Name	Symbol
	Shrubs and Trees(continued)	
Arctostaphylos mariposa	Mariposa manzanita	
Arctostaphylos patula	Green manzanita	
Arctostaphylos pringlei	Manzanita	
Arctostaphylos pungens	Pointleaf manzanita	
Artemisia arbuscula	Low sagebrush	
Artemisia longifolia	Longleaf sagebrush	
Artemisia nova	Black sagebrush	
Artemisia tridentata	Big sagebrush	Artr-l
Artemisia species	Sagebrush	Artem
Berberis nervosa	Oregon grape	
Berberis repens	Creeping barberry	Bere
Carnegiea (Cereus) sp.	Giant cactus	
Ceanothus cordulatus	Mountain whitethorn	
Ceanothus cuneatus	Wedgeleaf ceanothus	
Ceanothus greggii	Desert ceanothus	
Ceanothus integerrimus	Deer brush	
Ceanothus prostratus	Squaw carpet	
Ceanothus velutinus	Snowbrush	Ceve
Cercidium species	Palo verde	
Cercocarpus betuloides	Birchleaf mountain-mahogany	Cebe
Cercocarpus breviflorus	Mountain-mahogany	
Cercocarpus ledifolius	Curlleaf mountain-mahogany	Cele
Cercocarpus montanus	True mountain-mahogany	
Chamaebatia foliolosa	Sierra mountain misery	
Chimaphila umbellata	Prince's pine	
Chrysothamnus nauseosus	Rubber rabbitbrush	Chna
Chrysothamnus viscidiflorus	Green rabbitbrush	Chvi
Cowania mexicana	Cliffrose	Come
Ephedra viridis	Green ephedra	
Eurotia lanata	Winterfat	
Fendlera rupicola	Fendlerbush	
Garrya wrightii	Wright silktassel	
Juniperus deppeana	Alligator juniper	
Juniperus occidentalis	Western juniper	
Juniperus osteosperma	Utah juniper	Juos
Juniperus scopulorum	Rocky Mountain juniper	Jusc
Olneya tesota	Desert ironwood	
Opuntia species	Cholla; pricklypear	
Pachystima myrsinites	Mountain myrtle	
Picea species	Spruce	
Pinus contorta	Lodgepole pine	
Pinus edulis	Pinyon pine	
Pinus jeffreyi	Jeffrey pine	
Pinus monophylla	Singleleaf pinyon pine	Pimo
Pinus ponderosa	Ponderosa pine	Pipo

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Scientific Name	Common Name	Symbol
	Shrubs and Trees (continued)	
Pinus sabiniana	Digger pine	
Populus tremuloides	Quaking aspen	Potr-1
Populus trichocarpa	Black cottonwood	Potr-2
Prosopsis juliflora	Honey or velvet mesquite	
Prunus andersonii	Desert peach	
Prunus emarginata	Bitter cherry	Prem
Prunus subcordata	Klamath plum	
Prunus virginiana	Chokecherry	Prvi
Pseudotsuga menziesii	Douglas fir	
Purshia glandulosa	Desert bitterbrush	Pugl
Purshia tridentata	Antelope bitterbrush	Putr
Quercus dumosa	Calif. scrub oak	
Quercus emoryi	Emory oak	
Quercus gambelii	Gambel oak	
Quercus Kelloggii	Black oak	
Quercus turbinella	Shrub live oak	
Quercus undulata	Wavyleaf oak	
Quercus vaccinifolia	Huckleberry oak	
Rhamnus californicus	Coffeeberry	
Rhamnus crocea	Hollyleaf buckthorn; redberry	
Rhus diversiloba	Poison oak	
Rhus ovata	Sugar sumac	
Rhus trilobata	Skunkbush	Rhtr
Ribes aureum	Golden currant	Riau
Rosa woodsii	Woods rose	Rowo
Rosa species	Rose	Rosa
Salix subcoerulea	Willow	
Salix species	Willow	Salix
Sambucus glauca	Blue elderberry	
Sarcobatus vermiculatus	Greasewood	
Shepherdia species	Buffaloberry	
Simmondsia chinensis	Coffeebush; jojoba	
Spiraea betulifolia	Spirea	
Symphoricarpos albus	Common snowberry	
Symphoricarpos longiflorus	Longflower snowberry	Sylo
Symphoricarpos occidentalis	Western snowberry	
Symphoricarpos vaccinoides	Roundleaf snowberry	
Tetradymia canescens	Gray horsebrush	
Vaccinium membranaceum	Big whortleberry	
Vaccinium scoparium	Grouse whortleberry	
Yucca baccata	Datil yucca	

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